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Report No. 0162-01TN-62-20

STRUCTURAL VERIFICATION TESTS OF THE AEROJET UTILITY VAN

AFBSD TECHNICAL NOTE BSD-TDR-62-330

CONTRACT NO. AF 33(600)-36610

AEROJET-GENERAL CORPORATION
SOLID ROCKET PLANT • SACRAMENTO, CALIFORNIA
A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

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Technical Note
AFBSD-TDR-62-330
AFBM Exhibit 58-1

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Prepared by

W. D. Hulse
Mechanical Environment Group

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CONTRACT NO. AF 33(600)-36610

Prepared for

HQ, AIR FORCE BALLISTIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND, USAF
AIR FORCE UNIT POST OFFICE
Los Angeles 45, California

Attn: Tech Data Center

Approved by:

C. C. Conway, Manager
Minuteman Program

AEROJET GENERAL

SOLID ROCKET PLANT SACRAMENTO, CALIFORNIA

A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

PREFACE

Acknowledgment is made to the following persons for the preparation of this report: W. D. Hulse, Mechanical Environment Group; H. E. Johnson, Environmental Test Operations; Max Halebsky, Minuteman Environmental Program; and D. P. Campbell, Technical Editor.

ABSTRACT

Structural tests to verify the acceptability of the Aerojet-General Utility van as a transport vehicle for second-stage Minuteman operational motors have been successfully completed. During the tests, the van and tie-downs were subjected to limit loads to determine stress levels at critical load points and to measure vehicle deflection and recovery from the downward and side loads imposed.

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I. INTRODUCTION

To verify the acceptability of the Aerojet-General Utility van as a transport vehicle for Minuteman second-stage operational motors, the van and motor-harness tie-downs were subjected to structural tests. These tests were conducted in conjunction with climatic environmental tests as described in AFBSD-TDR-62-331, "High- and Low-Temperature Tests of the Aerojet Utility Van."

II. SUMMARY

The Aerojet Utility van and tie-downs successfully met structural criteria. The van and tie-downs were subjected to limit loads to determine stress levels at critical load points and to measure vehicle deflection and recovery from the downward and sideward loads imposed.

III. TECHNICAL DISCUSSION

A. TEST UNITS

1. Test Facility

The tests were performed at the structural test facility of the Aerojet, Sacramento, Solid Rocket Plant. Hydraulic load actuators were used in the tests and a load factor of 1.0 was equal to 13,000 lb.

2. Aerojet Utility Van and Tie-downs

Aerojet Utility van, model VR-01152A, serial number 372911 (AF 348874), was the test vehicle. The van had been modified in accordance

III, A, Test Units (cont.)

with Aerojet drawing T-492674A. Figure 1 shows the van installed in the test stand and Figure 2 shows the harness tie-down attached to the Boeing operational harness.

3. Test Motor and Harness

Minuteman motor 44TR-1, serial number 519578, cast with propellant simulant, was the test motor. The motor was supported in the van by a Boeing operational harness, PN 25-18032.

B. INSTRUMENTATION AND DATA RECORDING

1. Eleven biaxial strain gages were located at critical van load points to determine stress levels (Figures 3 through 5). The strain gages were Baldwin-Lima-Hamilton type AX-5 gages designed to register strain to 20,000 microin/in.

2. One 50K and two 20K Baldwin-Lima-Hamilton load cells were used to record applied load.

3. A standard Aerojet balance and calibration unit with Kintel III BF amplifiers was used to check out the load cells.

4. The recording oscillograph was a Consolidated Electronics Corp. (CEC) model 5-119P4-36 with CEC-318 galvonometers.

5. Two horizontal reference datum lines of piano wire were installed approximately 4 in. below the walls of the van and parallel to the bottom

III, B, Instrumentation and Data Recording (cont.)

of the van for measuring deflection. Preload, at-load, and postload measurements were taken at 12 locations (Figure 6) in Phase 2 of the test and at 14 locations in Phase 3.

6. Two dial gages with 3-in. stroke indicators were located under the center of the van to measure deflection at data points 9 and 10 (Figure 6). Two dial gages with 1/2-in. stroke indicators were located under the rear axle to measure rear axle deflection.

7. Measurements taken at each of the data points were as follows:

a. Prior to load application.

b. Two minutes after the load had been applied.

c. After removal of the applied load.

C. TEST CONDITIONS

1. General

The Aerojet Utility Van was instrumented and placed in the test stand as shown in Figures 1 and 7 for the forward and aft load tests, Phase 1, which were performed on 20 August 1962. Phase 3, the side-loading test, was performed 21 August. The motor was then removed from the van and the van was prepared for the downward-loading test, Phase 2, which was performed on 28 August.

2. Test Phases

The structural tests were conducted in three phases as follows:

a. Phase 1

III, C, Test Conditions (cont.)

With the motor and harness secured in the van to provide a downward vertical load factor of 1.0, additional forward and aft loads of 2.0 were applied and maintained for 5 min. Figure 8 shows the method of applying forward and aft loads. Strain-gage measurements were recorded during this test phase.

b. Phase 2

With the van emptied of the motor and harness, a downward load of 3.0 was applied at the areas of harness wheel contact with the van rails. The load was applied evenly and simultaneously to the four points of contact by the hydraulic actuators acting against two beams extending through the side access doors of the van. The load was maintained for 5 min. Both strain-gage and deflection measurements were recorded during this test phase. Figures 9 and 10 show the downward-load test setup.

c. Phase 3

With the motor and harness secured in the van to provide a downward vertical load factor of 1.0, a side load factor of 1.0 was applied to act through the center of gravity of the motor. The load was maintained for 5 min. As in Phase 2, deflection and recovery measurements were recorded in addition to the strain-gage measurements. Figures 11 through 13 show the side-load test setup.

D. TEST RESULTS

Tables 1 through 4 list the recorded maximum strain for each phase of the test. Tables 5 and 6 show deflection and recovery data for Phases 2 and 3,

III, Test Results (cont.)

respectively. Load-vs-time plots for the forward- and aft-load tests of Phase 1 are shown in Figures 14 and 15, respectively. Figures 16 and 17 are load-vs-time plots for Phases 2 and 3, respectively. Appendix A is the Integrated Testing and Inspection documentation as contained in the Minuteman Engineering and Inspection Summary (MEIS). Appendix B is the Operations Log for the tests.

First postdeflection measurements taken at the close of Phase 2 differed from the predeflection measurements by approximately 1/2 in. This difference was caused by the normal loss of air in the air-bag suspension system during load application. Minimal air loss results in activation of the system's rotary air-control valve by the mechanical sensing linkage. To obtain correct postdeflection measurements, the system was bled and repressurized to the starting pressure.

Appendix C, Structural Analyses Summary Sheet, presents calculations of stress analyses of the transport tie-down fittings within the van, the aircraft tie-down fittings outside the van, and the stress analyses of the Aerojet-designed transport cradles.

IV. CONCLUSIONS

All test objections were achieved. The Aerojet Utility van and motor tie-downs successfully withstood the load forces applied in the three test phases. There was no evidence of structural failure or permanent deformation. The van with tie-downs, therefore, qualifies structurally as an acceptable transport vehicle for Minuteman second-stage operational motors.

TABLE 1

Maximum Strains Imposed During Forward-Load Test, Utility Van Test Phase 1

Functions	Maximum Strain (Micro in./in.) (+)	(-)	Stress $\frac{lb}{in^2}$
S1-X	12.87	0	386.1
S1-Z	33.12	0	993.6
S2-XY	185.60	7.25	5568.0
S2-YX	9.80	749.70	2249.8(-)
S3-7	464.72	0	464.7
S3-Z	168.98	2.84	1689.8
S4-Y	2.94	183.75	1837.5(-)
S4-Z	45.57	0	455.7
S5-X	4.29	22.88	686.4(-)
S5-Y	2.96	42.92	1287.6(-)
S6-X	60.06	0	1801.8
S6-Y	0	153.70	4611.0(-)
	R-2 Record		
S7-Y	0	113.16	1131.6(-)
S7-Z	2.80	36.40	364.0(-)
S8-X	21.76	0	652.8
S8-Y	30.36	4.14	910.8
S9-X	93.84	0	2815.2
S9-Y	79.65	10.80	2389.5
S10-Y	0	8.40	84.0(-)
S10-Z	21.92	0	219.2
S11-X	48.30	1.38	1449.0
S11-Y	5.48	10.96	328.8(-)

NOTE: (+) Indicates upward deflection on the record, (-) Indicates Downward deflection.

TABLE 2

Maximum Strains Imposed During Aft-Load Test,
Utility Van Test Phase 1

Functions	Maximum Strain (Micro in./in.) (+)	(-)	Stress(psi)
S1-X	0.	8.58	257.4(-)
S1-Z	0.	37.26	1117.8(-)
S2-XY	0.	337.85	10135.5(-)
S2-YX	784.00	0	23520.0
S3-Y	325.60	0	3256.0
S3-Z	0	107.25	1072.5(-)
S4-Y	91.14	0	911.4
S4-Z	0	48.51	485.1(-)
S5-X	60.06	0	1801.8
S5-Y	19.24	37.00	1110.0(-)
S6-X	0	57.20	1716.0(-)
S6-Y	75.40	0	2262.0
	R-2 Record		
S7-Y	0	20.70	207.0(-)
S7-Z	33.60	1.40	336.0
S8-X	1.36	17.68	530.4(-)
S8-Y	0	17.94	538.2(-)
S9-X	100.74	0	3022.2
S9-Y	22.95	12.15	688.5
S10-Y	0	61.61	616.1(-)
S10-Z	1.37	16.44	164.4(-)
S11-X	0	67.62	2028.6(-)
S11-Y	23.29	13.70	698.7

NOTE: (+) Indicates trace deflection upwards on record. (-) Indicates Downward deflection.

TABLE 3

Maximum Strains Imposed During Downward-Load Test, Utility Van Test Phase 2

Functions	Maximum Strain (Micro in./in.) (+)	(-)	Stress (psi)
S1-X	0	46.08	1382.4(-)
S1-Z	18.85	31.90	957.0(-)
S2-XY	0	307.34	9220.2(-)
S2-YX	50.40	0	1512.0
S3-Y	14.60	33.58	335.8(-)
S3-Z	No. Calibration Available		- - - -
S4-Y	224.51	14.30	2245.1
S4-Z	18.24	41.04	410.4(-)
S5-X	0	74.97	2249.1(-)
S5-Y	58.80	19.11	1764.0
S6-X	0	260.19	7805.7(-)
S6-Y	79.38	155.82	4674.6(-)
	R-2 Record		
S7-Y	No Trace on Record		- - - -
S7-Z	12.69	19.74	197.4(-)
S8-X	0	26.22	786.6(-)
S8-Y	14.70	2.94	441.0
S9-X	72.61	0	2178.3
S9-Y	119.85	11.28	3595.5
S10-Y	6.90	19.32	193.2(-)
S10-Z	0	45.87	458.7(-)
S11-X	20.85	0	625.5
S11-Y	0	27.93	837.9

NOTE: (+) Indicates upward deflection on the record, (-) Indicates Downward deflection.

TABLE 4

Maximum Strains Imposed During Side-Load Test,
Utility Van Test Phase 3

Function	Maximum Strain (Micro in./in.) (+)	(-)	Stress (psi)
S1-X	5.76	14.40	432.0(-)
S1-Z	0	24.31	729.3(-)
S2-XY	0	21.75	652.5(-)
S2-YX	102.48	29.28	3074.4
S3-Y	88.80	7.40	888.0
S3-Z	50.05	54.34	543.4(-)
S4-Y	172.50	12.00	1725.0
S4-Z	49.50	49.50	495.0
S5-X	0	14.70	441.0(-)
S5-Y	36.00	4.50	1080.0(-)
S6-X	60.90	62.35	1870.5(-)
S6-Y	40.88	48.18	1445.4(-)
	R-2 Record		
S7-Y	99.36	107.64	1076.4(-)
S7-Z	14.00	77.0	770.0(-)
S8-X	29.92	35.36	1060.8(-)
S8-Y	39.20	30.80	1176.0
S9-X	142.80	0	4284.0
S9-Y	0	29.70	891.0
S10-Y	0	63.00	630.0(-)
S10-Z	0	75.90	759.0(-)
S11-X	13.60	29.92	897.6(-)
S11-Y	13.70	52.06	1561.8(-)

NOTE: (+) Indicates trace deflection upward on record. (-) Indicates downward deflection.

TABLE 5

Defelection and Recovery Measurements, Phase 2,
Utility Van Test*

LOCATION	PRE LOAD	AT LOAD	POST LOAD
1	4.062	4.0	4.0
2	4.562	3.75	4.312
3	4.312	3.625	4.562
4	4.312	3.375	4.562
5	4.437	3.562	4.75
6	4.187	3.50	4.50
7	4.00	3.50	4.062
8	3.75	3.625	4.68
9	.000	.637	.25
10	.000	.879	.25
11	.000	.355	.039
12	.000	.467	.0625
Rt Bag Press	25#	90#	30#
Lt Bag Press	20#	70#	17#

* Measurements, in inches, show variations between van sub-frame and reference datum lines

TABLE 6

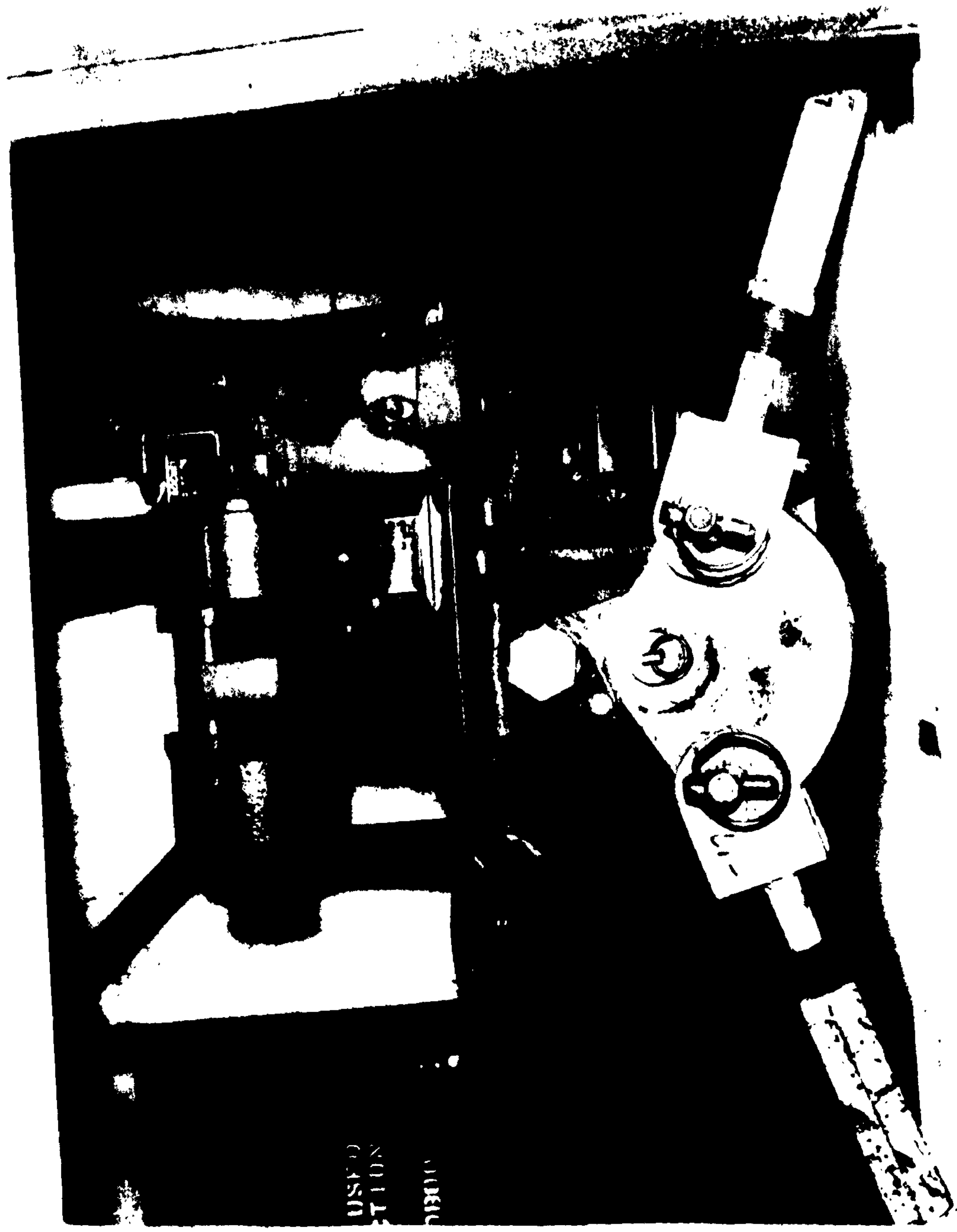
Defelection and Recovery Measurements, Phase 3, Utility Van Test*

LOCATION	PRE LOAD	AT LOAD	POST LOAD
1	4.42	7.625	4.50
2	4.73	7.75	4.81
3	5.06	7.93	5.12
4	5.50	8.125	5.43
5	4.72	3.109	5.68
6	5.12	2.84	5.12
7	5.75	2.75	4.68
8	4.25	2.67	4.25
9	0.0955	0.25	0.810
10	0.094	0.07	0.356
11	9.0	7.75	8.93
12	9.0	7.875	8.68
13	0.074	0.310	0.124
14	0.073	0.201	0.082
Rt Bag Press	75#	0#	60#
Lt Bag Press	75#	20#	65#

* Measurements, in inches, show variations between van sub-frame and reference datum lines

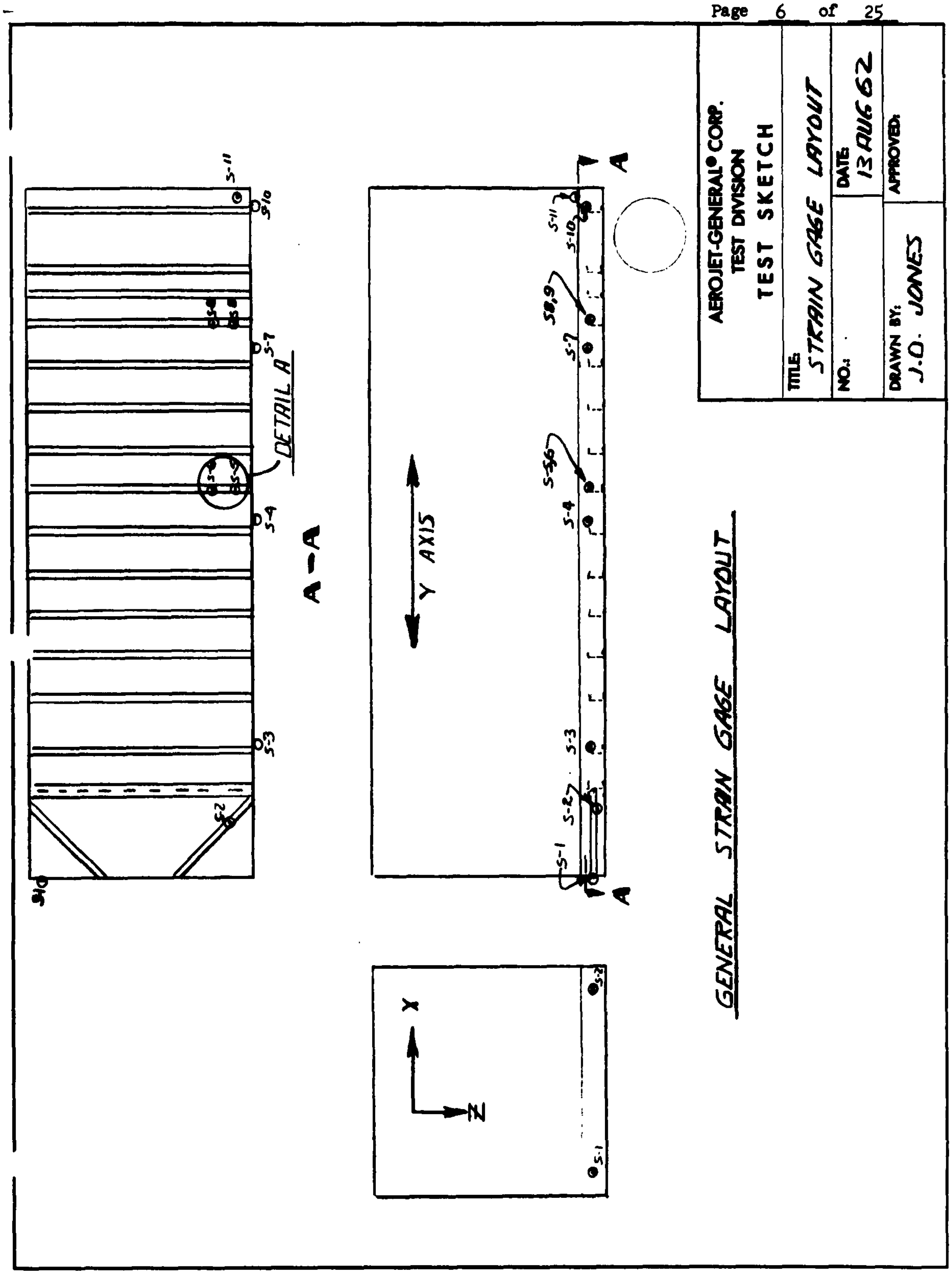
Aerojet Utility Van in Test Stand

Figure 1



Motor-Harness Tie-Down Attached to Boeing Harness

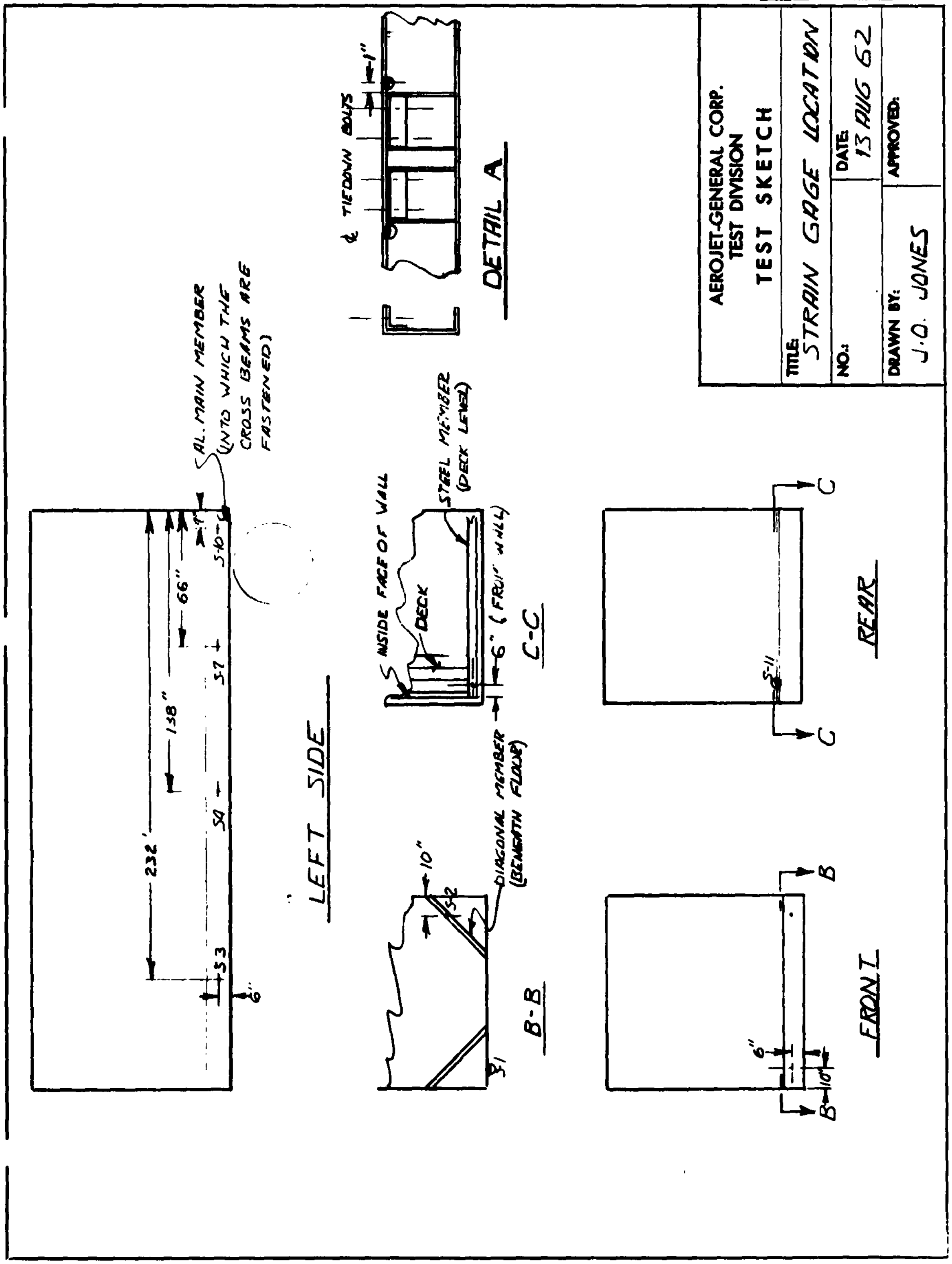
Figure 2



Location of Strain Gages on Utility Van, X, Y, and Z Axis

FIGURE 1

Figure 3

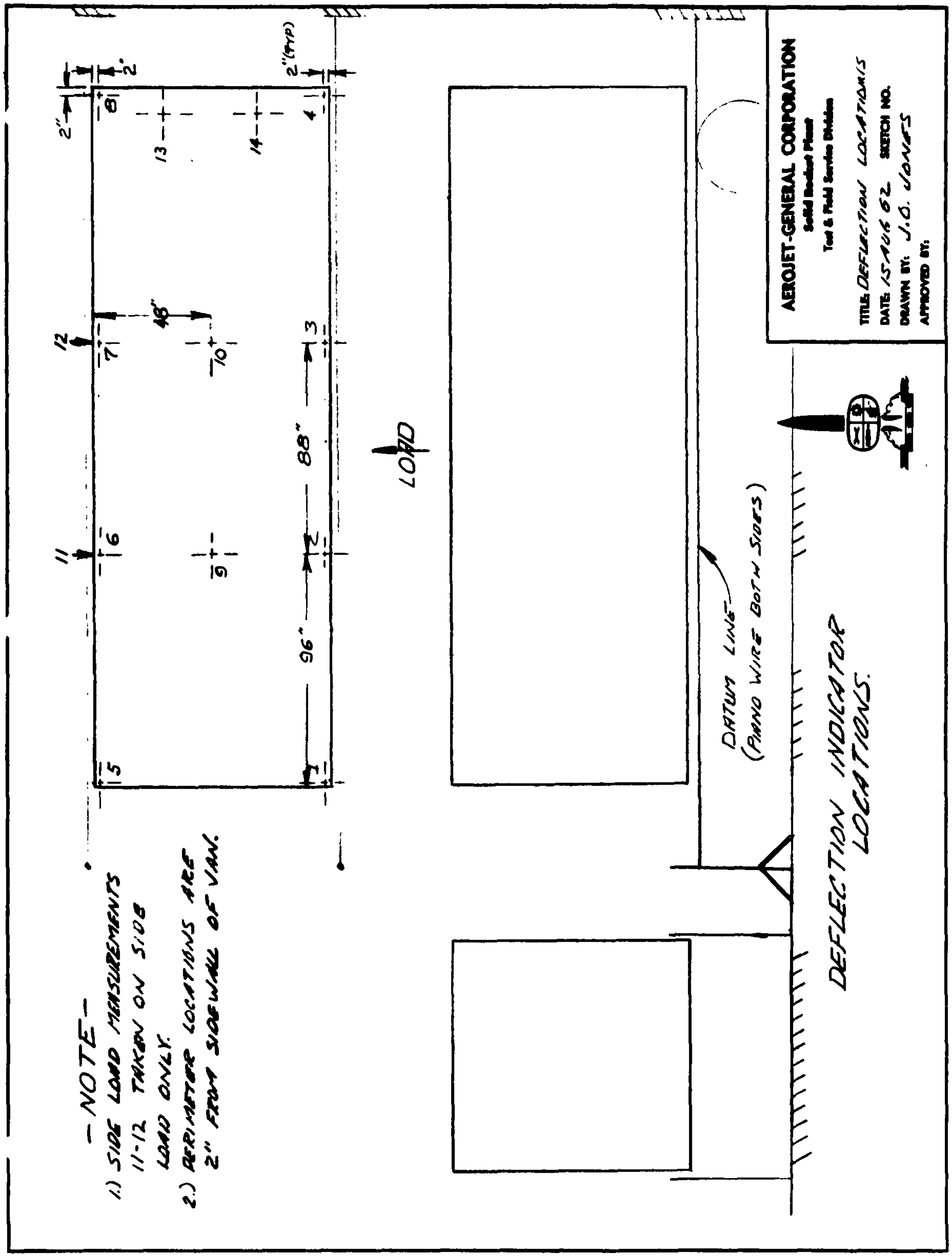


Detail of Strain-Gage Locations

Figure 4

Wiring Detail of Six Strain-Gage Locations

Figure 5



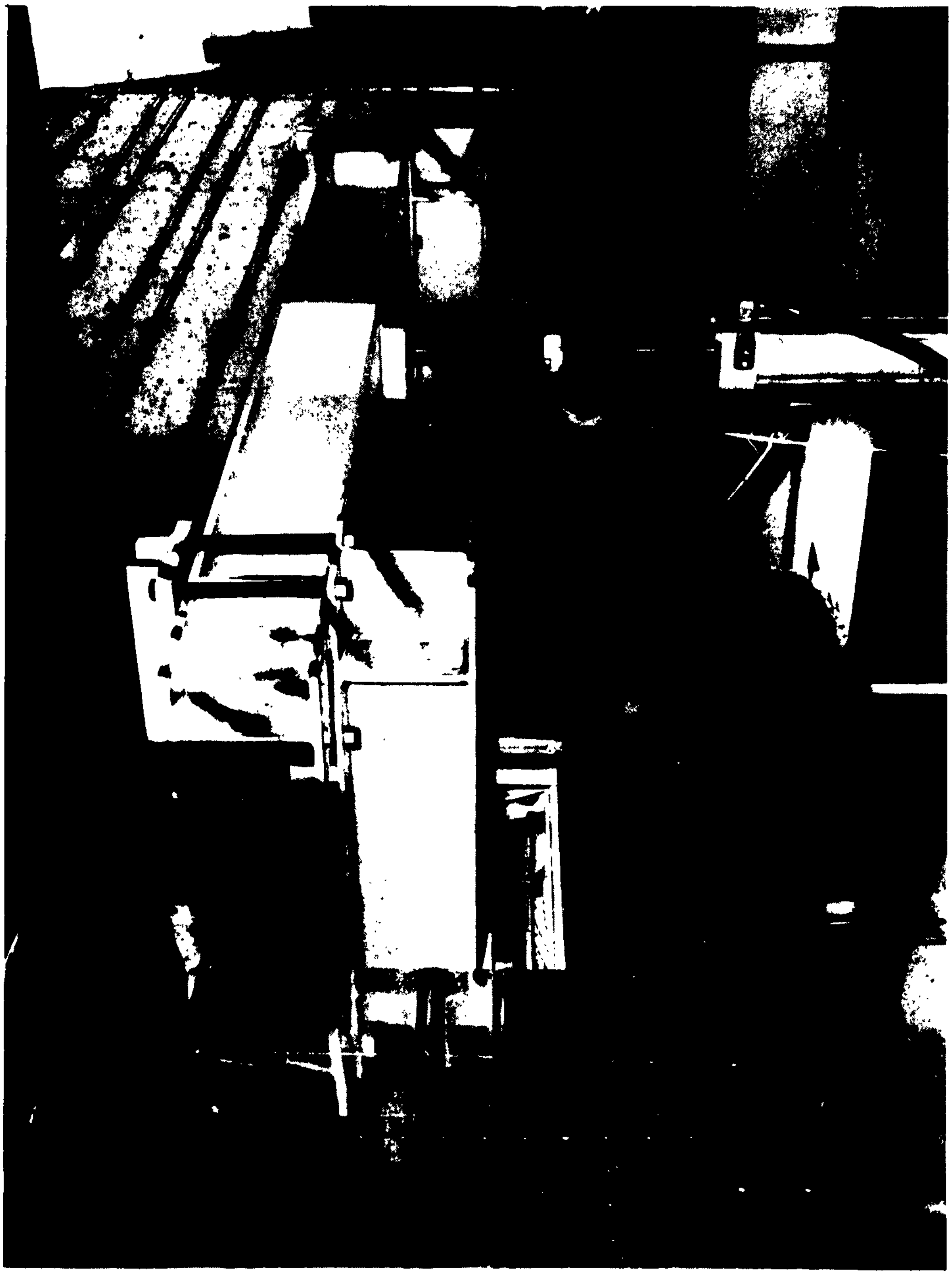
Deflection Indicator Locations

Figure 6

Forward View of Utility Van in Test Stand

Figure 7

Method of Applying Forward and Aft Loads



Cross Beams Extending Through Van Access Doors,
Downward-Load Test

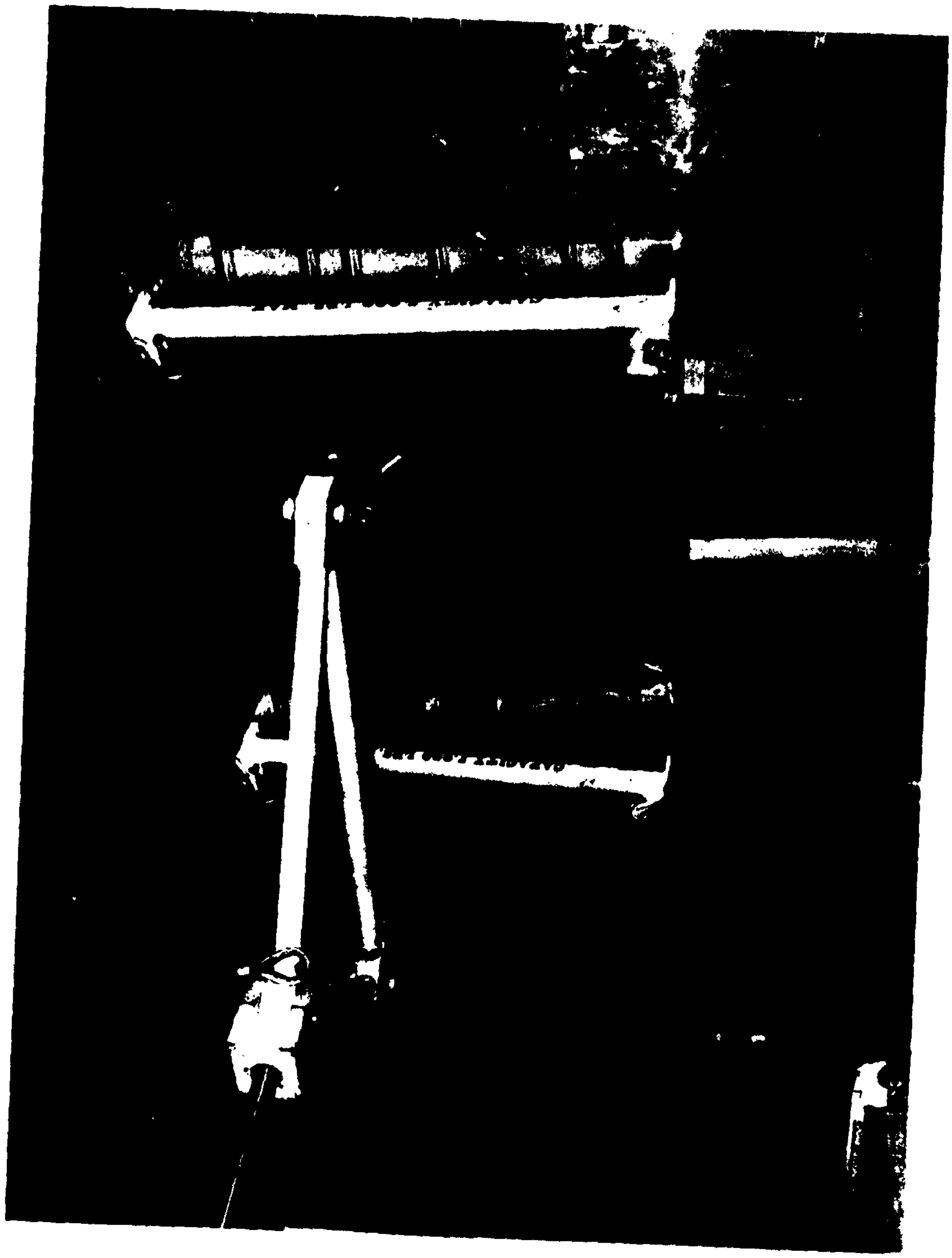
Figure 9

Side View of Test Setup, Downward-Load Test

Figure 10

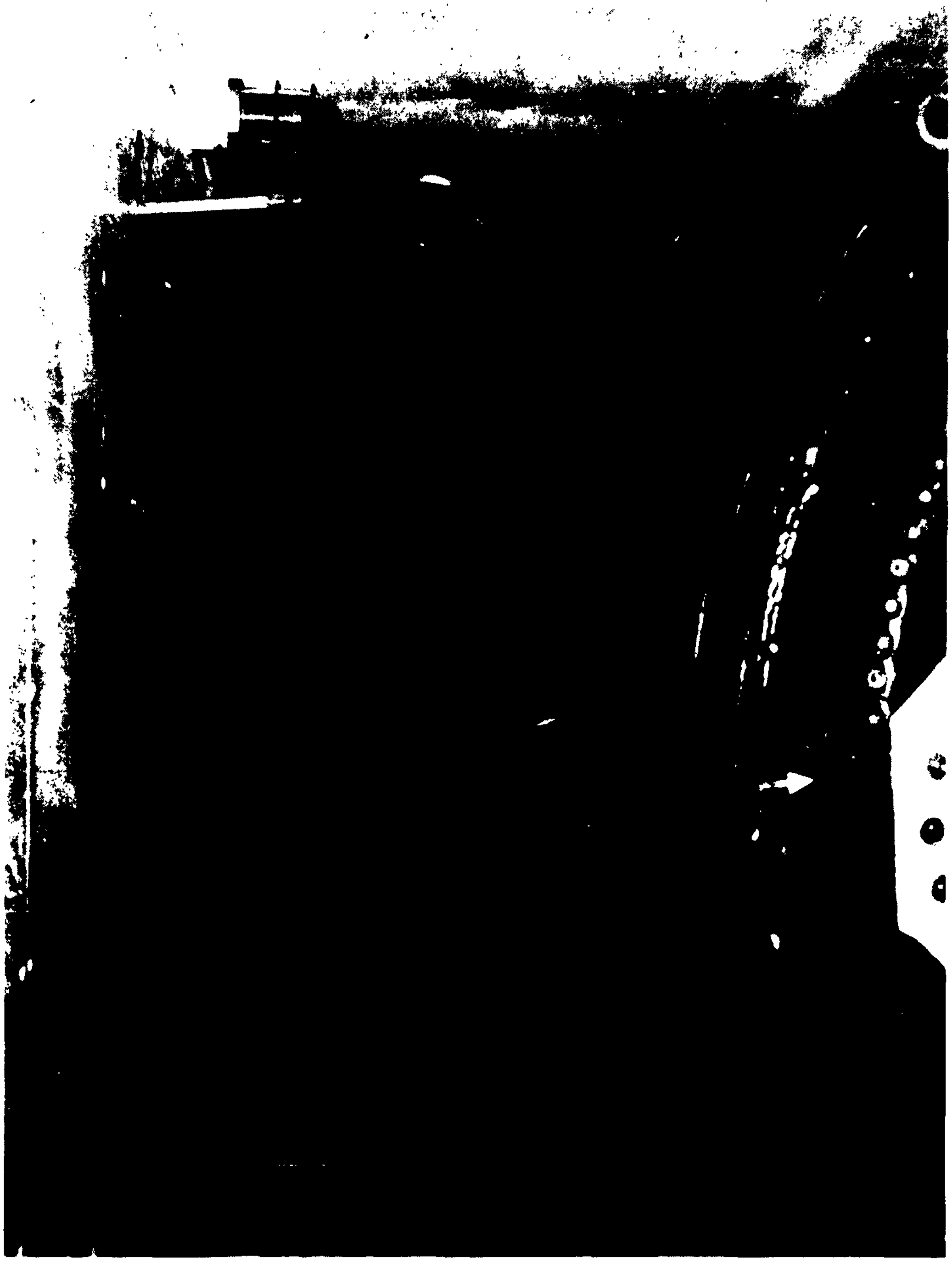
Hydraulic Load Actuator With Load-Measuring Device,
Side-Load Test

Figure 11



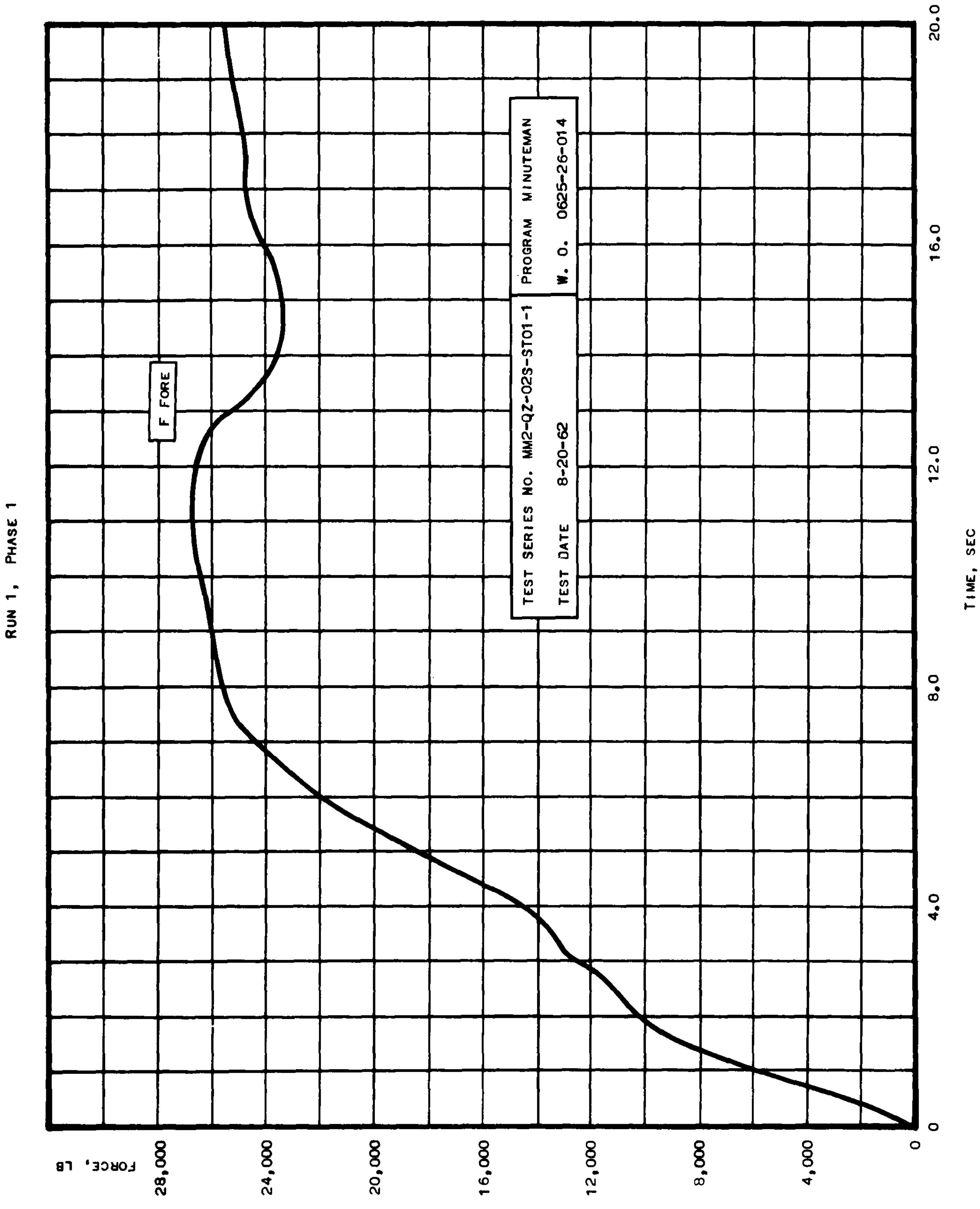
Arm Extension of Hydraulic Load Actuator, Side-Load Test

Figure 12



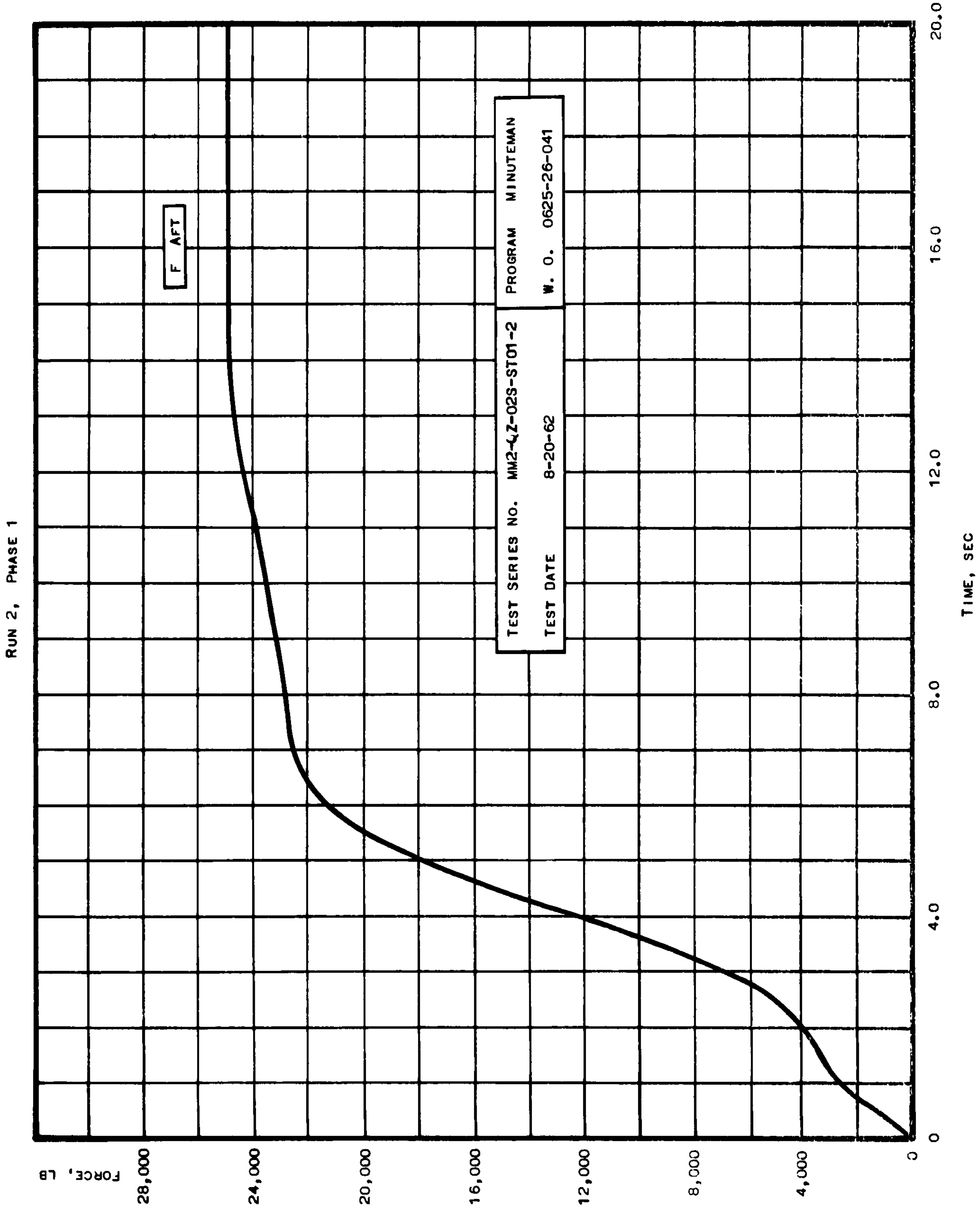
Motor-Belt Attachment to Load Actuator, Side-Load Test

Figure 13



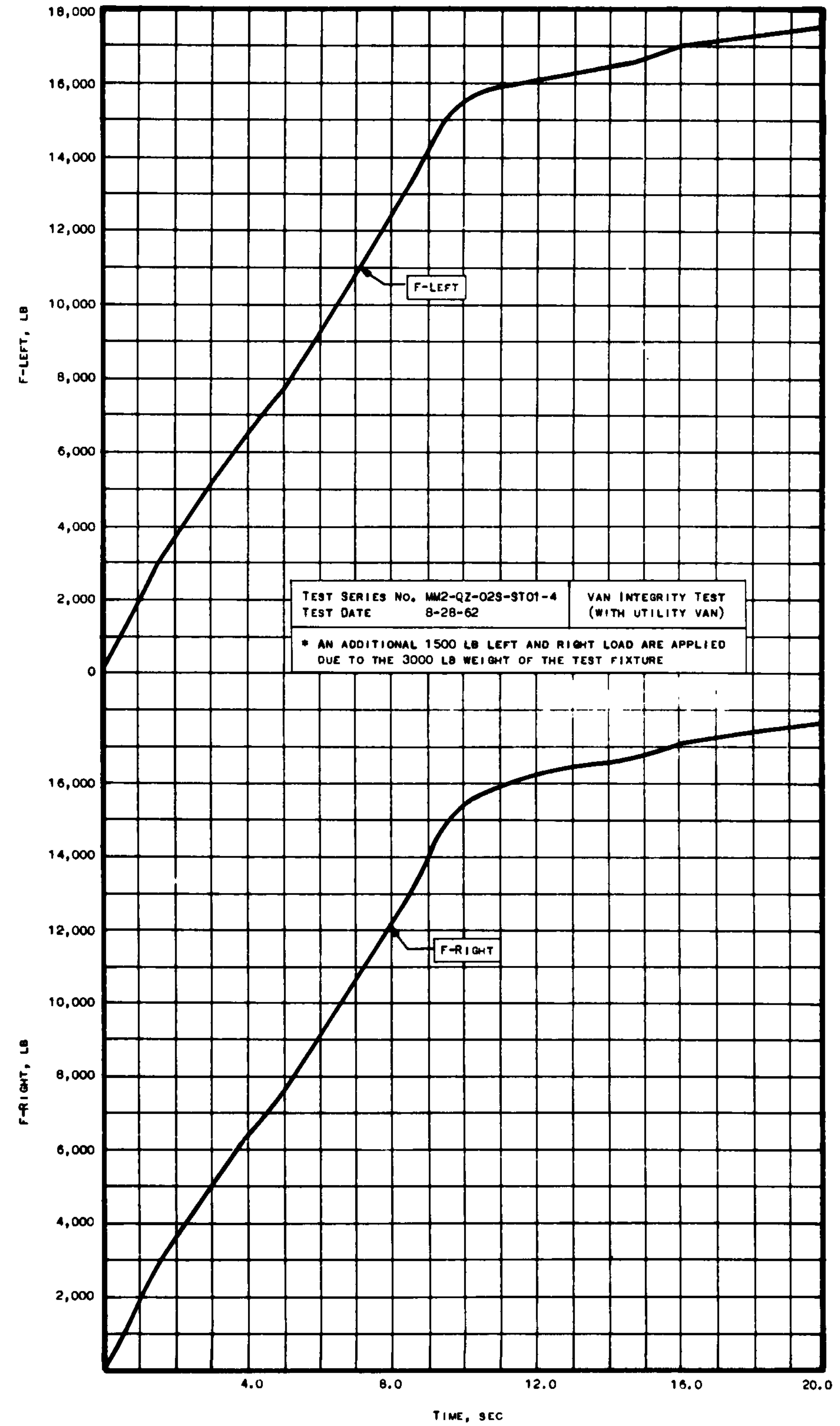
Load vs Time, Foward-Load Test

Figure 14



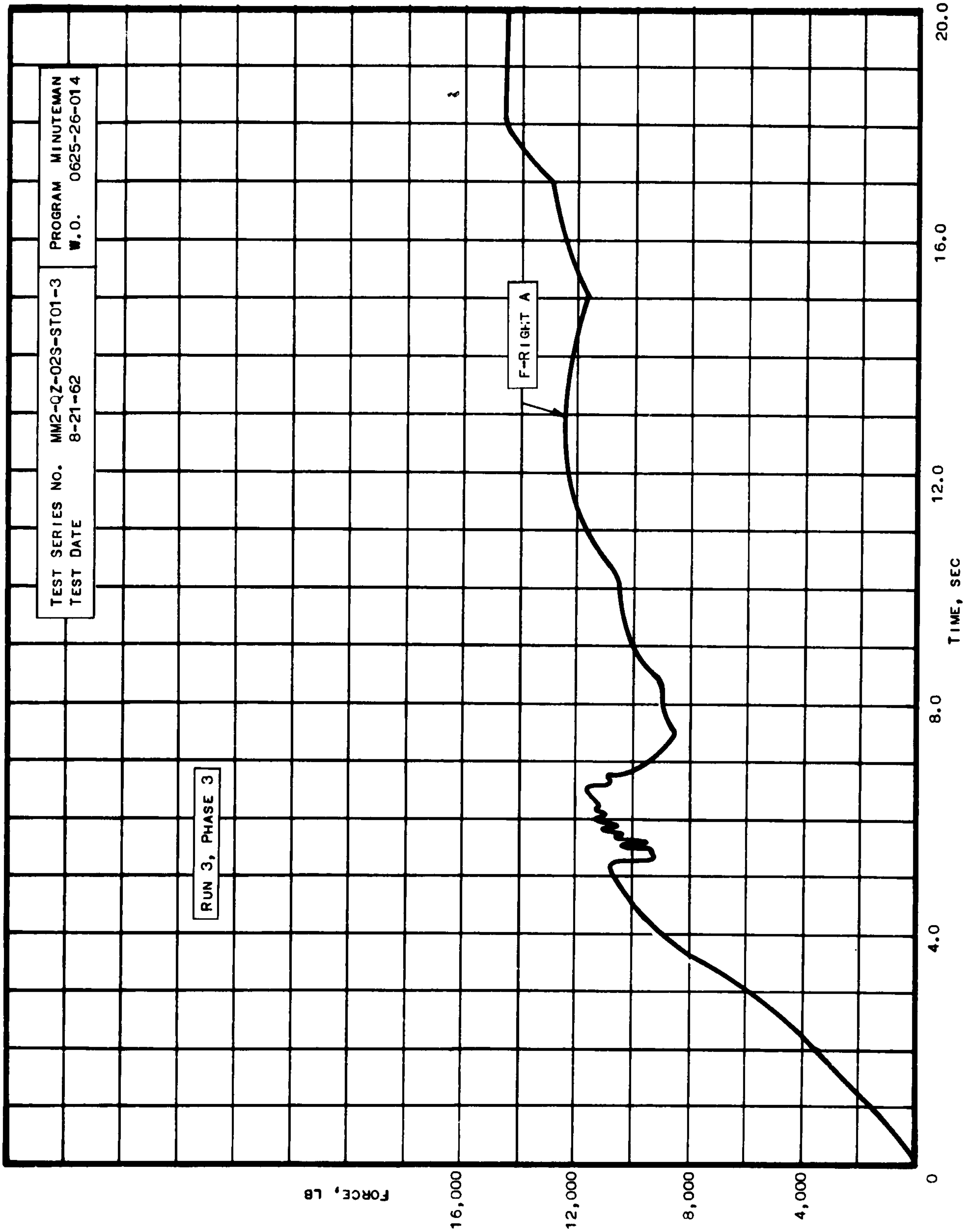
Load vs Time, Aft-Load Test

Figure 15



Load vs Time, Downward-Load Test

Figure 16



Load vs Time, Side-Load Test

Figure 17

APPENDIX A

DOCUMENTATION OF TESTING

AND INSPECTION

AGC 3-063-032

AEROJET-GENERAL CORPORATION
SOLID ROCKET PLANT SACRAMENTO, CALIF.

MINUTEMAN
INTEGRATED PLANNING RECORD

CODE 101	MEIS NO.	DATE	PAGE OF	MIPR NO.
	HT-64	20 Aug 62	1/1	1

PREV. MEIS:

NEXT MEIS: N.A.

APPLICABLE DWGS.: T-492674A (Utility Van)
T-430460
T-430467

APPLICABLE SPECS.: Test Plan 751A

TITLE: Structural Verification of AGC Utility Van

ENGINE NO. 44-TR1 SERIAL NO. 519578

Utility Van, VR-1152A, S/N ~~37295~~ 37291

ENGINEERING INSTRUCTION CHANGES	OP. INIT.	INSPECTION SUMMARY CHANGES	INSP. STAMP	DATE AND REMARKS
No Engineering Changes	[illegible]	~~No Inspection Changes~~ 5.4.11 5.4.12 } ADDED, SEE 5.4.13 } PP. 10, 12 5.4.14 } ADDED, SEE 5.4.16 } PP. 12.		

APPROVED: PROJECT Jack W Sohe
* LINE 1
* SAFETY
* WHEN REQUIRED

APPROVED: INSPECTION PLANNING Ernest L. [illegible]

AEROJET GENERAL CORP.
SOLID ROCKET PLANT SACRAMENTO CALIF.

MINUTEMAN

ENGINEERING AND INSPECTION SUMMARY

CODE	MEIS NO.	ISSUE DATE	PAGE
101	HT- 64	17 August 1962	1 OF 18

TITLE Utility Van Environmental Verification (STRUCTURAL)

ENGINE NO. 44TR-1 Utility Van
SERIAL NO. 519578 S/N 3729[illegible]1

ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
1. After completion of each step disclosed in the Engineering Instructions of the MEIS, the assigned Test Engineer or Technicians shall apply his initials in the column provided. 2. During actual operation, revisions to Testing Requirements contained in the MEIS will be made on the MIPR. Changes will be initiated by the cognisant test engineer. All entries on the MIPR should be made in a legible fashion with black ink. In no case shall the MEIS be altered except for recording the required data as requested. 3. When the MEIS is complete the assigned test engineer shall apply his signature in the space provided. The completed MEIS will then be forwarded to the Aerojet-General Quality Control Department. 4. Notify Inspection before proceeding with paragraphs marked with a double asterisk (**). Inspection disposition of previous or current operations required.	MTH	INSPECTOR: When a characteristic of this summary is not complied with, initiate an I.R. and record its number in the remarks column. Record on the I.R. the information that is necessary to give a complete description of the discrepancy. This information should include the methods and/or the materials used such as pressures, cure times, temperatures, weights, bonding agents and substitute materials. INDICATION OF INSPECTION ACCEPTANCE 1. Date and Stamp off related operations on AGC 3-109-439-2 and/or AGC 3-109-432-2 traveler tag. 2. Stamp off each characteristic of this summary as it is complied with. 3. Forward completed integrated planning to Line One (1) Inspection Office. NOTE: THIS INTEGRATED PLANNING IS NOT VALID AND SHALL NOT BE USED BY INSPECTION UNLESS COVER PAGE (MIPR) AGC 3-053-032, IS APPROVED BY INSPECTION PLANNING. EACH PAGE OF THE MEIS SHALL HAVE THE APPROVAL OF INSPECTION PLANNING AND QUALITY CONTROL ENGINEERING.		

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MRIS NO. HT-64	ISSUE DATE 17 August 1962		PAGE 2 OF ___
ENGINEERING INSTRUCTIONS	**OP. INIT.**	**INSPECTION SUMMARY**		**INSP. STAMP**	**REMARKS AND DATE**
1.0 Scope	MDH				
1.1 This Minuteman Engineering and Inspection Summary covers the Engineering and Inspection requirements necessary to verify the structural integrity of the utility van and tie-down equipment under limit loads, prior to qualification of the 2nd Stage Minuteman Transporter (Utility Van) for operational use.					
2.0 References Required	MDH	2.0 All references used corresponds with number, Change letter or Revision listed on MIPR. Method: Visual			
2.1 Test Plan 751A, AGC Minuteman Division.	MDH				
2.2 Drawing T-492674A, Trailer, Transport, 44" motor.	MDH				
2.3 Contract change notification #182 to L. C. SA14 to AF 33(600)-36610.	MDH				
2.4 Applicable drawings, sketches, specifications, and procedures in accordance with Page 1 of attached MIPR.	MDH				
3.0 Items to be Tested	MDH				
3.1 AGC 2nd Stage Minuteman Transporter, T-492674. S/N to be specified on the attached MIPR. Installed in the transporter is an inert 2nd Stage Minuteman Motor, 44TR-1, S/N 519578.	MDH				
3.2 Boeing Operational Harness, P/N 25-18032.	MDH				

AGC 3-052-602

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 3 OF ___

ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
4.0 Test Equipment Required	MTH			
4.1 T-430460 (Basic loading fixture)	MTH			
4.2 T-430467 (Side loading adapters)	MTH			
4.3 2 ea. 20K load cell	MTH			
4.4 1 ea. 50K load cell	MTH			
4.5 1 ea. 50K Servo-controlled Hydraulic Actuator	MTH			
4.6 2 ea. 20K Servo-controlled Hydraulic Actuator	MTH			
4.7 1 ea. 50K B-L-H Mono-Axial Assy. 2 ea. [illegible] B-L-H Mono-Axial Assy.	MTH MTH			
4.8 Thrust adapters as required.	MTH			
4.9 Hydraulic supply system.	MTH			
4.10 2 ea. dial indicators (3" stroke)	MTH			
4.11 Mechanics rule.	MTH			
4.12 Eleven (11) B-L-H Type A5X strain gages.	MTH			
4.13 Oscillographs as required.	MTH			
4.14 Miscellaneous hand tools as required.	MTH			
5.0 Engineering Requirements	MTH			
5.1 Pre-Test Preparations.				
5.1.1 Initial inspection of components.	MTH	5.1.1.1.1 Verify transporter P/N of transporter agrees with S/N listed on MIPR.		8-28-62
5.1.1.1 List S/N of the following.	MTH	Method Visual:		
5.1.1.1.1 Utility Van ~~342874~~ 372[illegible]	MTH	Record S/N 37291		

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 4 OF ___

ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
5.1.1.1.2 BAC Harness 0000016	MOH	5.1.1.1.2 Verify Boeing operational harness P/N is 25-18032.		
5.1.1.1.3 Inert 44" Motor TR-1 [illegible]	MOH	Method: Visual: Record S/N [illegible]		
5.1.1.2 Inspection of general condition of van, motor, and harness. (List any discrepancies.)	MOH	5.1.1.1.3 Verify inert motor is 44TR-1 S/N 519578. Method: Visual: TR-1		
5.1.1.3 Verify tie-down and motor/harness installation per acceptable MEIS (Line 1) and Inspection buy off on same accomplished.	MOH	5.1.1.2 Motor, Van, and Harness, free of any apparent physical damage or deformation. Method: Visual		
5.1.1.4 Verify security at all tie-down points.		5.1.1.4 Verify all components are securley installed. Method: Visual		
5.1.2 Instrumentation.	MOH			
5.1.2.1 Install (11) Type A5X (or equiv.) strain gages at locations as called out in Test Plan 751A.	MOH			
5.1.2.1.1 Method of installation per standard Test Area practices.	MOH	5.1.2.1.1 Strain gages installed per Test Plan 751A. Method: Visual		
5.1.2.1.2 Verify satisfactory calibration and operation of each gage.	MOH			
5.1.2.1.3 List strain-gage number by actual designation and var location. (Attach sketch if required.)	MOH			

AGC 3-052-602

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 5 OF ___

ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
5.1.2.1.4 List S/N and range of load cells used.	MWH	5.1.2.1.4 Verify load cells have acceptable calibration and record S/N, P/N, and due date.		
Foreward S/N Z2166, 50K #		Forward S/N Z2166 P/N 50K Due date 11-3-62		
Side S/N 18481, 20K #		Side S/N 18481 P/N 20K Due date 11-2-62		
Down S/N 15681, 20K #		Down S/N 15681 P/N 20K Due date 11-2-62		
18481 #, 20K #		(Other) S/N 18481 P/N 20K Due date 11-2-62		8-20-62
		Method: Visual		
5.1.3 Facility preparation.	MWH			
5.1.3.1 Install basic test fixture, T-430460-202, -204, and -205.	MWH			
5.1.3.2 Position van within center-line of basic fixture.	MWH			
5.1.3.3 Holding fore end of van in air with overhead crane, install fifth wheel support fixture.	MWH			
5.1.3.4 Lower van to fifth wheel support. Verify secure connection made.	MWH			

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 6 OF ___

ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
5.1.3.5 Verify wheels of van (inside) are against transverse restraint blocks.	MTH			
5.1.3.6 Install wheel tie-down cables. Tighten until no slack is apparent.	MTH			
5.2 Foreward Loading Test.	MTH			
5.2.1 Tripod, T-430460-401, installed on aft end of inert motor. Verify (24) 1/4-24 bolts torqued.	MTH			
5.2.2 50K mono-axial assy. installed on tripod.	MTH			
5.2.3 50K load cell assembled to mono-axial assy.	MTH			
5.2.4 50K servo-controlled hydraulic actuator installed on cross beam, T-430460-205.	MTH			
5.2.5 Load cell to actuator connection made. Verify correct alignment. (±1/16" from level per 12".)	MTH			
5.2.6 Hydraulic lines connected to actuator.	MTH			
5.2.7 Verify satisfactory operation of system with 1000# loading. (15 sec. duration)	MTH			
5.2.8 Review and approve oscillograph record of functional checkout. (Re-range if necessary.)	MTH	5.2.8 Verify all Recording equipment has acceptable calibration. Method: Visual	36	8-20-62

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 7 OF ___

ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
5.2.9 Take still photos of the test setup, showing motor, test hardware, and instrumentation.	MTH	5.2.9 Verify still photos taken prior to test of the following: Test setup, Motor, Test hardware, Instrumentation. Method: Verify per photographer		8-20-2
5.2.10 Verify motion picture setup ready.	MTH	5.2.10 Verify motion picture cameras setup. Method: Verify per photographer		8-20-2
5.2.11 Verify all interested people are present, or have been notified. Test Coord. 5809 (Neesham) Project 3856 (Halebsky) STL 3856 Structures 3939 (Weip) Inspection 2568	MTH			
5.2.12 Verify instrumentation ready.	MTH			
5.2.13 Apply foreward load (+Fy) of 26,000 lbf (1200#), through CG of motor. This load to be applied within five (5) seconds. 2100 F.S. (time) ____ 26,000# (time)	MTH			
5.2.14 Hold the 26,000 lbf load for five (5) minutes. 2100 Start Time 2105 Finish	MTH			
5.2.15 Inspect motor, harness, tie-downs and van for any evidence of structural failure or deformation. List below any discrepancies.	MTH	5.2.15 Motor, Van, and Harness free of any apparent physical damage. Method: Visual		8-20-2

AEROJET GENERAL

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 8 OF ___

ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
5.2.16 Review data and approve before continuing next test.	[illegible]			
5.3 Aft Loading Test (Fy)	[illegible]			
5.3.1 Verify items 5.2.1 through 5.2.11 completed and re-checked.	[illegible]			
5.3.2 Apply aft load of 26,000 lbf (±200#) through CG of motor. Load to be applied within 5 seconds. 2200 F.S. (time) _____ 26,000# (time)	[illegible]			
5.3.3 Hold the 26,000 lbf load for five (5) minutes. 2200 Start Time 2205 Finish	[illegible]			
5.3.4 Inspect motor, harness, tie-downs, and van for any evidence of structural failure or deformation. List below any discrepancies.	[illegible]	5.3.4 Motor, Van, and Harness free of any apparent physical damage. Method: Visual	336	8-2[illegible]
NOTE: Condition of king-pin must be inspected carefully as all loads are re-acted here.				

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 9 OF ___

ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
5.3.5 Inspection of all equipment completed and approval given to proceed to next test.	MCH			
5.3.6 All fore and aft loading equipment dismantled.	MCH			
5.4 Side Loading Test (F_s)	MCH			
5.4.1 Pre-test preparations.	MCH			
5.4.2 20K servo-controlled hydraulic actuator installed on T-703343 Rucker test stand.	MCH			
5.4.3 20K load cell assembled to 20K actuator arm.	MCH			
5.4.4 20K B-L-H mono-axial assy. connected to load cell.	MCH			
5.4.5 Loading yolk and belt assy., T-430467 installed on motor and connected to mono-axial assy.	MCH			
5.4.5.1 Verify alignment and security of force transfer members.	MCH			
5.4.6 Re-check motor/harness/tie-down security.	MCH			
5.4.7 Take still photos of the test setup.	MCH	5.4.7 - Verify still photos taken of test set-up. Method: Verify per photographer		8-20-2
5.4.8 Verify readiness of the motion picture setup.	MCH	5.4.8 Verify motion pictures cameras setup. Method: Verify per photographer		8-20-2
5.4.9 Verify instrumentation is ready.	MCH			

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MBIS NO. HT-64	ISSUE DATE 17 August 1962		PAGE 10 OF ___
ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY		INSP. STAMP	REMARKS AND DATE
5.4.10 Service air-bag suspension system to 80-100 psi. List actual pressure below. 90 PSI	MGH				
5.4.11 Pre-test deflection measurements taken.	MCH	5.4.11 VERIFY PRE-TEST DEFLECTION MEASUREMENTS TAKEN. Method: Visual.		(stamp)	8-21-2

NOTE: List all measurements here. (Distance from reference plane)

Location	Pre-Test	At-Load	Post-Test
1	4.42	7.625	4.50
2	4.73	7.75	4.81
3	5.06	7.93	5.12
4	5.50	[illegible].125	5.43
5	4.72	[illegible].109	5.68
6	5.12	2.84	5.12
7	5.75	[illegible].75	4.68
8	4.25	[illegible].67	4.25
9	0.0955	0.25	.816
10	0.094	0.07	.356
13 Axle	0.074	.10	.124
14 Axle	0.073	.01	.082
Air Bag (R)	75	0	80
Pres. (L)	75	20	65
11	9.0	7.75	8.93
12	9.0	7.875	8.68
[redacted]	[redacted]	[redacted]	[redacted]

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962	PAGE 13 OF ___

ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
5.4.19 If results of 5.4.17 and 5.4.18 are satisfactory, dismantle test setup and ship van to Bldg. 48 Line 1. Test Comp. 1900 Time 8-21-62 Date	BCH			
5.5 Downward (Fx) Loading Test.	MCH			
5.5.1 Pre-test preparations.	MCH			
5.5.1.1 Initial inspection.	MCH			
5.5.1.1.1 Van arrives back in SRPTA @ 0900 hrs. 8-22-62 date.	MCH	5.5.1.1.1 Verify still photos taken of test setup. Method: Verify per photographer	IA W38	8-28
5.5.1.1.2 King pin, rails, air suspension, and van general condition checked and found to be O.K. (or list discrepancies below.	MCH	5.5.1.1.2 Verify motion picture cameras setup. Method: Verify per photographer		8-28
5.5.1.2 Van positioned in test fixture	MCH			
5.5.1.3 Fifth wheel hook-up made and verified secure.	MCH			
5.5.1.4 Wheel tie-downs installed.	MCH			

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962		PAGE 14 OF ___
ENGINEERING INSTRUCTIONS	**OP. INIT.**	**INSPECTION SUMMARY**		**INSP. STAMP**	**REMARKS AND DATE**
5.5.1.5 Instrumentation hook-up initiated.	MTH				
5.5.1.6 T-430460-302, -306 simulated wheels and loading beams installed	MTH				
Fore	MTH				
Aft	MTH				
5.5.1.7 Longitudinal load transfer beams, T-430460-301, assembled to -302 beams.					
Right	MTH				
Left	MTH				
5.5.1.8 20K mono-axial assy., load cell, and hydraulic actuator installed on each side.					
Right	MTH				
Left	MTH				
5.5.1.8.1 Verify identical setup and pre-load on each side (to prevent un-equal loading).	MTH				
5.5.1.9 Install hydraulic lines to actuators.					
Right	MTH				
Left	MTH				

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MRIS NO. HT-64	ISSUE DATE 17 August 1962		PAGE 12 OF ___
ENGINEERING INSTRUCTIONS	**OP. INIT.**	**INSPECTION SUMMARY**		**INSP. STAMP**	**REMARKS AND DATE**
5.4.12 Apply side load ($-F_z$) of 13,000 lbf (±100#), through motor CG. Apply within five (5) seconds. 11:45 F.S. (time) 1145 13,000# (time)	MCH	[illegible]		7A V30	
5.4.13 Hold the 13,000 lbf side load for five minutes. 1145 start time.	MCH				
5.4.14 After two (2) minutes of static load, take van deflection measurements and record in 5.4.11.	MCH	[illegible]			
5.4.15 Release the load after five (5) minutes. 1150 completion time.	MCH	[illegible]			
5.4.16 Take recovery measurements and record in 5.4.11.	MCH				[illegible]
5.4.17 Inspect motor, harness, tie-downs, and van for any evidence of structural failure or deformation. List any discrepancies.	MCH	5.4.17 Motor, Van, and Harness free of any apparent physical damage. Method: Visual		7A W30	8 21
5.4.18 Review data and ascertain all test objectives accomplished.	MCH				

AGC 3-052-602

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ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
5.5.1.10 Verify, by low-pressure functional check, equal loading rate at each side.	MCH			
5.5.1.11 Take still photos of the test setup.	MCH			
5.5.1.12 Verify movie setup ready.	MCH			
5.5.1.13 Verify instrumentation ready.	MCH			
5.5.1.14 Verify all interested parties present or notified.	MCH			
5.5.1.15 Service air-bags to 80-100 psi - record actual pres. below.	MCH			
5.5.1.16 Take pre-test deflection measurements. Record below. (Distance from reference)	MCH			

Location	Pre-Test	At-Load	Post-Test
1	4.662	4.00	4.0
2	4.562	3.75	4.312
3	4.312	3.625	4.562
4	4.312	3.375	4.562
5	4.437	3.562	4.75
6	4.187	3.50	4.50
7	4.00	3.50	4.062
8	3.75	3.50	4.68
9 Forward	.000	3.625	.25
10 Aft	.000	.637	.25
Axle R	.000	.879	.039
Axle L	.000	.355	.0625
		.467	
Rt. Bag Pres.	25#	90#	20#
Lt. Bag Pres.	20#	70#	17#

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ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
5.5.2 Downward Loading Test	MCH			
5.5.2.1 Apply downward (Fx) load of 39,000 lbf (±300#), within five (5) seconds, through the four simulated harness wheels. NOTE: This is 19,500 lbf at each actuator. 1345 F.S. (time) _____ 39,000# (time) Hold load for five (5) minutes.	MCH			
5.5.2.2 After two (2) minutes of static load, record van deflections in para. 5.5.1.15.	MCH			
5.5.2.3 Release load after five (5) minutes. 1350 Comp. time.	MCH			
5.5.2.4 Take recovery measurements, and record in 5.5.1.15.	MCH			
5.5.2.5 Inspect condition of van rails, structural members, floor, etc. for evidence of structural failure or deformation. List discrepancies below.	MCH	5.5.2.5 Motor, Van, and Harness free of any apparent physical damage. Method: Visual		8-28

MINUTEMAN ENGINEERING AND INSPECTION SUMMARY	CODE 101	MEIS NO. HT-64	ISSUE DATE 17 August 1962		PAGE 17 OF ___
ENGINEERING INSTRUCTIONS	**OP. INIT.**	**INSPECTION SUMMARY**		**INSP. STAMP**	**REMARKS AND DATE**
5.5.2.6 Review data and ascertain all test objectives accomplished.	MDH				
5.5.2.7 If results of 5.5.2.5 and 5.5.2.6 are satisfactory, dismantle test setup.	MDH				
5.5.3 All oscillograph records and data sheets identified and forwarded to Data Reduction.	MDH				
5.6 The four (4) access holes in side of van repaired.	MDH				
5.7 All entries on this MEIS complied with and signed off.	MDH	5.7 All preceding characteristics have been complete by inspection. Method: Review MEIS and MIPR			8-28
5.8 All testing accomplished per Test Plan 751A and this MEIS and attached MIPR.	MDH				
M. D. Hubel Test Engineer Environmental Testing Dept.					

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ENGINEERING INSTRUCTIONS	OP. INIT.	INSPECTION SUMMARY	INSP. STAMP	REMARKS AND DATE
Written By J. D. Sohl Minuteman Environmental Program Manager Environmental Testing Dept. Solid Rocket Plant Approved By W. W. Lauderdale Section Supervisor Environmental Testing Section Environmental Testing Dept. Solid Rocket Plant		Quality Control Planning Quality Engineer		

APPENDIX B

OPERATIONS LOG

ST Form 1013 Rev 2
Aerojet-General
Corporation, SRP

AGC 3-128-631

TEST OPERATIONS
MOTOR LOG OF TIME VS OPERATION

W.O. NO. E-00488

STRUCTURAL VERIFICATION
TYPE OF TEST

C.R. NO. ______ TEST ENGINEER W. D. Hulse

PROGRAM MINUTEMAN TEST SERIES MM2-QZ-02S-ST01 SHEET 1 OF 1

TEST SPECIMEN Utility Van VR-1152A

DATE	TIME	OPERATION
8-10-62	2330	Van arrived SRPTA for structural testing.
8-13-62	1800	Strain gage installation started.
	2400	Strain gage installation complete.
8-14-62	1400	Van moved into test position. Mechanical setup started.
8-20-62	1800	Mechanical setup complete.
	2100	Phase I-A test conducted - forward loading.
	2200	Phase I-B test conducted - aft loading. Side loading hardware
		installation started.
8-21-62	1000	Side loading hardware installation completed.
	1145	Phase 3 test conducted.
	1300	Removal of hardware begun.
	1900	Van left SRPTA for motor removal at 4841.
8-22-62	0900	Van returns.
	1600	Hardware and plumbing installed.
	1900	Brake accumulator tank over-pressurized and destroyed.
		Test detained awaiting repair.
8-27-62	1600	Temporary system installed to pressurize air bags.
8-28-62	1200	Hydraulic system set up.
	1345	Phase 2 of test conducted.
	1500	Removal of hardware begun.
8-29-62	1500	Van returned to gate #1.

APPENDIX C

STRUCTURAL ANALYSES

SUMMARY SHEET

SUBJECT ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS		DATE Nov 27, 1961 WORK ORDER 0380-22-905
BY WEG	CHK BY T. Cummins	DATE 12/11/61

DESIGN PURPOSE: TRANSPORT VEHICLE FOR LIVE MOTOR ROAD TESTS.

ANALYSIS REQUEST: MAX HALEBSKY, DEPT 5210. {x 3836, x 5721}

APPLICABLE DESIGN CRITERIA:

A) FROM STL (SEE P. 1a FOR ENVELOPE)
1) 3g's DOWN
2) 1g UP
3) 1g LATERAL
4) 2g FORE & AFT
5) 40 MPH MAX

THESE ARE LIMIT LOADS; USE 1.5 S.F. ON ULTIMATE UNIT STRESSES

B) AGC SRP CRITERIA (SECTION 5.4) → DOES NOT GOVERN
1) COVERS EQUIPMENT FOR IN-PLANT USE ONLY, AND LIMITS ALL HAZARDOUS TRANSPORT TO 10 MPH MAXIMUM SPEED.

LOADS:

LIVE ASSEMBLED MOTOR:	11,900 LB	
HANDLING CONTAINER:	1810 LB	
TRANSPORT CRADLES:	750 LB (PAIR)	
	14,460 LB	SAY 14,500 LB

TRANSPORT TIEDOWNS & RAILS:	500 LB	
	14 960 LB	SAY 15,000 LB

SUBJECT: LOAD COMBINATIONS – STL CRITERIA

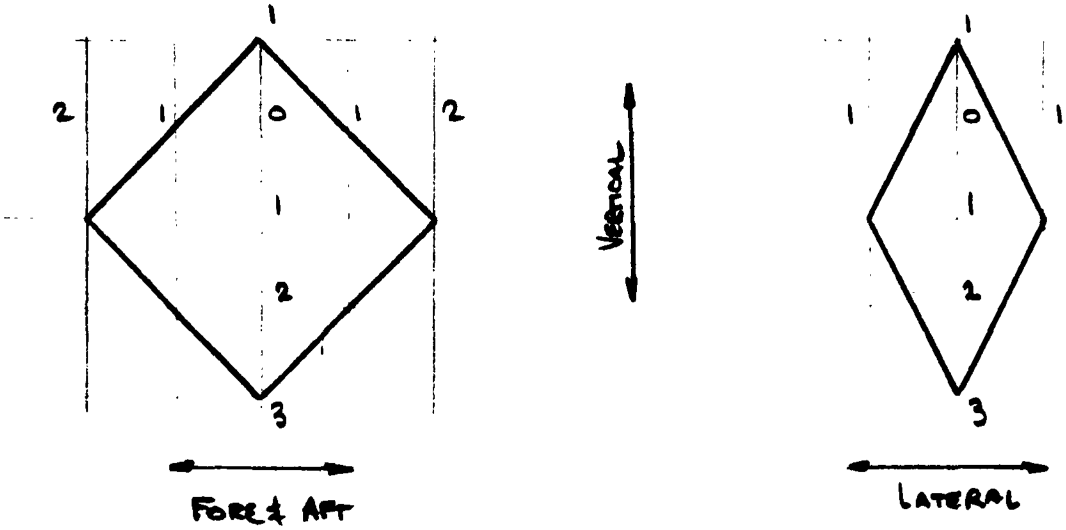
DATE: 11/27/61

WORK ORDER: 0380-22-905

BY: WIEG

CHK BY: T CUMMINS

DATE: 12/11/61



THESE ARE LIMIT LOADS; DESIGN FACTOR REQ'D: 1.5 ON ULTIMATE ALLOWABLE UNIT STRESSES.

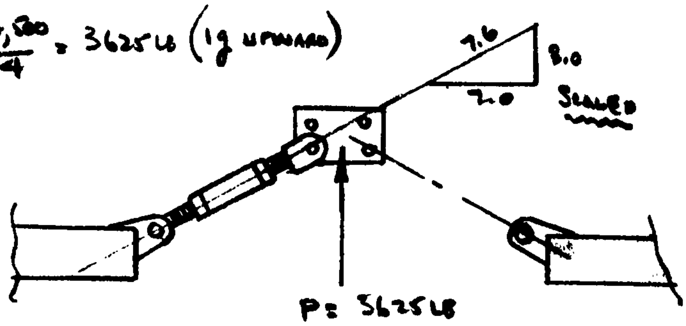
SUBJECT: ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS

DATE: 11/29/61
WORK ORDER: 0380-22-905
BY: WIES
CHK BY: T CAMMINS
DATE: 12-11-61

CHECK BAC CONTAINER TIEDOWN:

UPWARD LOAD:

$P = \frac{14,500}{4} = 3625$ LB (1g UPWARD)



AXIAL COMPONENT OF VERTICAL LOAD $= \frac{3625}{2}\left(\frac{7.6}{3.0}\right) = 4600$ LB

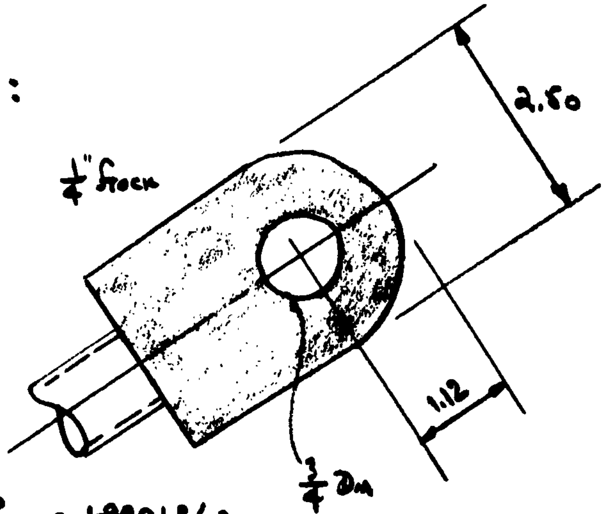
UNIT STRESS IN $\frac{3}{4}$" ROD $= \frac{4600}{.302} = 15,250$ LB/IN² (LESS THAN HALF YIELD VALUE)

THRD. ROOT AREA

LUG AT CRADLE ADAPTER:

UNIT TENSILE STRESS @ HOLE

$= \frac{4600}{.125(2.50-.75)(2)} = 5250$ LB/IN² (LOW)



2.50
-.75
1.75
.88

$f_{sh} = /(1.12-.38)(2)(.25)$
.370
12,960

UNIT BEARING STRESS @ HOLE $= \frac{4600}{.25(.75)(2)} = 6900$ LB/IN² (LOW)

WELD ATTACHMENT BETWEEN $\frac{3}{4}$" ROD AND LUGS:

LINEAL WELD UNIT LOAD $= \frac{4600}{6(.75)} = 1020$ LB/LIN. INCH

NET EQUIV. DIA'S.

FOR $\frac{1}{4}$" WELD, $f_s = \frac{1020}{.707(.25)} = 5800$ LB/IN² (LOW)

SUBJECT: Analysis of Rough Road Test Trailer Tiedowns

DATE: 11/28/61
WORK ORDER: 0380-22-905

BY: Wieg
CHK BY: T Cummins
DATE: 12-12-61

Check BAC Container Tiedown - Cont'd:

Upward Load - Cont'd:

Lug at Cradle Adapter - Cont'd:

End: $l = \frac{2.5 - .75}{2} = \frac{1.75}{2} = .88$ in

$S = \frac{bl^2}{6} = \frac{.25(.88)^2}{6} = .0323$ in^3

Unit Bending Stress on Lug: (Consider Fixed-End Beam)

$$f_b \text{ at end} = \frac{M}{S} = \frac{wl^2}{12(S)(2)} = \frac{\frac{4600}{.75}(.75)^2}{12(.0323)(2)} = 4450 \text{ lb/in}^2$$

.388

At midspan: $l = .75$

$S = \frac{bl^2}{6} = \frac{.25(.75)^2}{6} = .0234$ in^3

$$f_b \text{ at midspan} = \frac{M}{S} = \frac{wl^2}{24(S)} = \frac{\frac{4600}{.75}(.75)^2}{24(.0234)} = 6150 \text{ lb/in}^2$$

.562

Unit Shear Stress at Lug: $f = \frac{P}{A} = \frac{4600}{.25(.75)(2)(2)} = 6100$ lb/in^2

Combining, Max Unit Stress (f_{max}) $\sim f_s + .25 f_b = 6100 + 1600 = 7700$ lb/in^2 (low)

SUBJECT	DATE
ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS	11/29/61
	WORK ORDER 0380-22-905

BY	CHK BY	DATE
WEBB	T Cummins	12.17.61

CHECK BAC CONTAINER TIEDOWN – CONT'D :

UPWARD LOAD – CONT'D:

LUG AT FLOOR YOKE:

WELD CONNECTION BETWEEN LUG & $2\frac{1}{2}$" O.D. SLEEVE:

$$\text{LINEAL WELD UNIT LOAD} = \frac{4600}{\frac{\pi(2.5)}{2}(2)} = 600 \text{ LB/LIN. INCH}$$
(LOW)

CHECK FLOOR YOKE IN BENDING AND SHEAR:

NOTE: MAX STRESSES OCCUR DURING FORE & AFT LOAD CONDITION SEE P. 8.

NOTE: SINCE $\frac{E}{D} = 1.5$ FOR HOLE, LUG BEARING, BENDING & SHEAROUT WILL NOT BE A PROBLEM. (REF. P. 8 & 4)

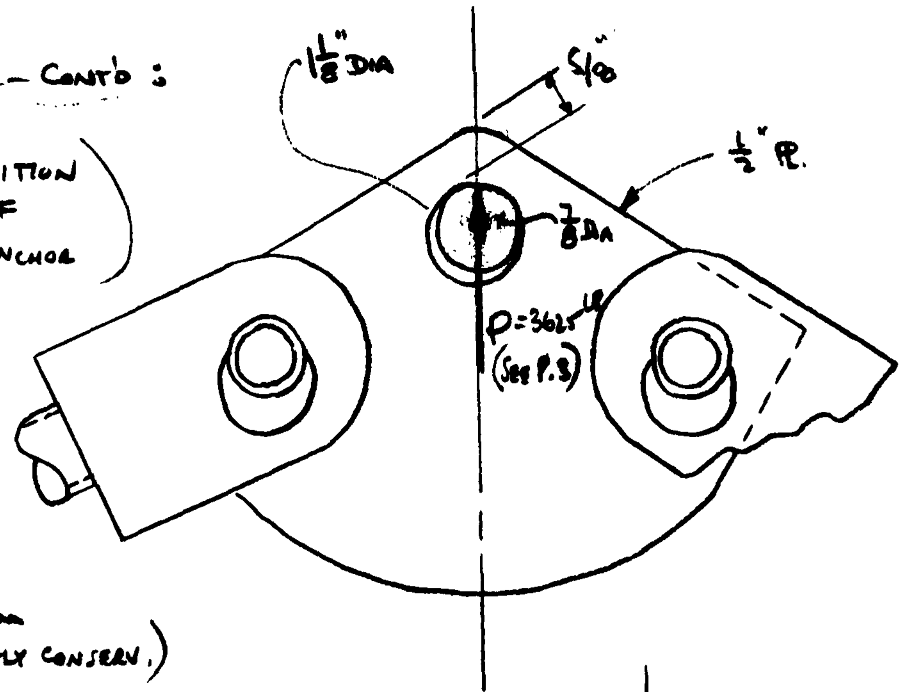
SUBJECT: ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS
DATE: 11/29/61
WORK ORDER: 0380-22-905
BY: WIEG
CHK BY: T CUMMINS
DATE: 12-12-61

CHECK BAC CONTAINER TIEDOWN - CONT'D:

UPWARD LOAD - CONT'D:

LUG AT CRADLE ADAPTER - CONT'D:

(SHADED AREA DENOTES POSITION & RELATIVE DIAMETER OF BAC SPRING-LOADED ANCHOR PIN.)



CONSIDER A FIXED-END BEAM LOADED AT MIDSPAN (SLIGHTLY CONSERV.)

$$\text{MAX MOM} = \frac{Pl}{8} = \frac{3625(1.12)}{8}$$

$$S = \frac{bh^2}{6} = \frac{.5(.625)^2}{6} = .0326\ \text{in}^3$$

$$f_b = \frac{M}{S} = \frac{3625(1.12)}{8(.0326)} = 15{,}500\ \text{LB/IN}^2$$

(THIS STRESS MUST BE MODIFIED BY A CURVED-BEAM FACTOR)

FROM CASE 1, TABLE VII, P.148 ROARK:

$$R = \frac{21}{32} \qquad C = \frac{7}{32}$$

$$\frac{R}{c} = \frac{25/32}{7/32} = 3.57$$

$$k_i = 1.30 - .10(.57) = 1.24$$

$$\text{MODIFIED } f_b = 1.24(15{,}500) = 19{,}200\ \text{LB/IN}^2$$

$$f_s = \frac{3625}{2(.5)(.44)} = 8200\ \text{LB/IN}^2$$

COMBINING:

$$f_{MAX} = 19{,}200 + .35(8200) = 22{,}100\ \text{LB/IN}^2$$

SUBJECT: ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS
DATE: 12/8/61
WORK ORDER: 0380-22-905
BY: WIEG
CHK BY: T CUMMINS
DATE: 12-12-61

CHECK BAC CONTAINER TIEDOWN – CONT'D:

FORE & AFT LOAD: (REFER TO P. 3)

AXIAL COMPONENT OF FORE & AFT LOAD $= \dfrac{\cancel{8}g\left(\frac{7.6}{7.0}\right)}{\cancel{8}2} = \dfrac{7.6}{7.0}\left(\dfrac{14,500}{2}\right) = 7900$ LB

NO. OF TIEDOWNS IN TENSION

UNIT STRESS IN $\frac{3}{4}$'' ROD $= \dfrac{7900}{.302} = 26,200$ LB/IN²

LOW FOR 4130

LUG AT CRADLE ADAPTER OK BY INSPECTION

UNIT BEARING STRESS AT LUG HOLE OK BY INSP.

WELD ATTACHMENT BETWEEN $\frac{3}{4}$'' ROD & LUG:

(SIMILAR TO P. 3)

$$f_{s\,(WELD)} = 5800\left(\frac{7900}{4600}\right) = 10,000 \text{ LB/IN}^2 \quad (\text{LOW})$$

LUG AT CRADLE ADAPTER:

(SIMILAR TO P. 4)

$$f_{MAX} = 7700\left(\frac{7900}{4600}\right) = 13,200 \text{ LB/IN}^2 \quad (\text{LOW})$$

SUBJECT: ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS
DATE: 12/11/61
WORK ORDER: 0380-22-905
BY: WIEG
CHK BY: T CUMMINS
DATE: 12-12-61

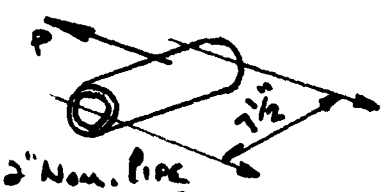
CHECK BAC CONTAINER TIEDOWNS – CONT'D:

FORE & AFT LOAD – CONT'D:

CHECK FLOOR YOKE IN BENDING & SHEAR:

$P = 7900$ (SEE P. 7)

$f_b = \frac{M}{S} = \frac{\frac{P\ell}{4}}{S} = \frac{7900\,(3.75)}{4\,(.56)} = 13,200$ LB/IN^2 (LOW)



2" NOM. PIPE
$S = .56$ IN^3
P 139 (AISC)

WELD ATTACHMENT @ ENDS OF PIPE IN SHEAR: $f_s = \frac{7900}{\pi(2.375)} = 1060$ LB/LIN INCH

O.D. (LOW FOR 1/4" WELD)

FLOOR YOKE IS FASTENED TO RAILS BY 4 – 1/2" BOLTS AT EACH END:

SHEAR/BOLT $= \frac{7900}{2\,(4)} = 990$ LB/BOLT

$f_s = \frac{990}{.126} = 7850$ LB/IN^2 (LOW)

THRD ROOT AREA

CHECK BAC CONTAINER TIEDOWNS - CONT'D:

FORE & AFT LOADS - CONT'D:

CHECK $\frac{3}{4}$" BOLT IN DOUBLE SHEAR: AT SPHERCO SWIVEL ATTACHMENT

FULL DIA. AREA = .442 IN^2

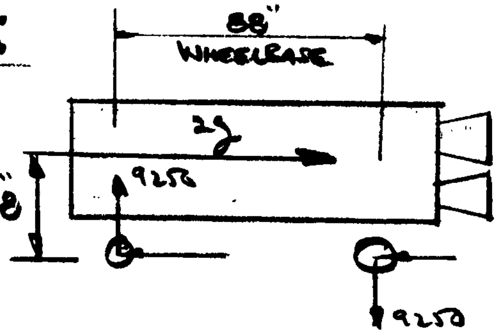
$$f_s = \frac{\overset{P.60}{7900}}{2(.442)} = 9000 \ LB/IN^2 \ (LOW)$$

(THIS MAKES THE PIP PINS AT OPPOSITE END ASSOCIATED WITH THIS CONNECTION OK BY COMPARISON)

SUBJECT: ANALYSIS OF ROUGH ROAD TEST TRAILER TIEDOWNS
DATE: 12/12/61
WORK ORDER: 0380-22-905
BY: WIEG
CHK BY: T CUMMINS
DATE: 12-12-61

BAC CONTAINER TIEDOWNS:

LOAD COMBINATIONS:



$$\text{PITCH LOAD} = \frac{2g\,(28)}{88} = 9250\ \text{LB AT EACH END}$$
(4625 LB / WHEEL)

$$\text{VERT LOAD} = \frac{14500}{4} = 4625\ \text{LB/WHEEL}$$

AT 1g DOWN + 2g's FORE OR AFT:

PITCH LOAD/WHEEL = 4625 LB
VERT LOAD/WHEEL = 3625 LB
1000 LB NET UPLIFT

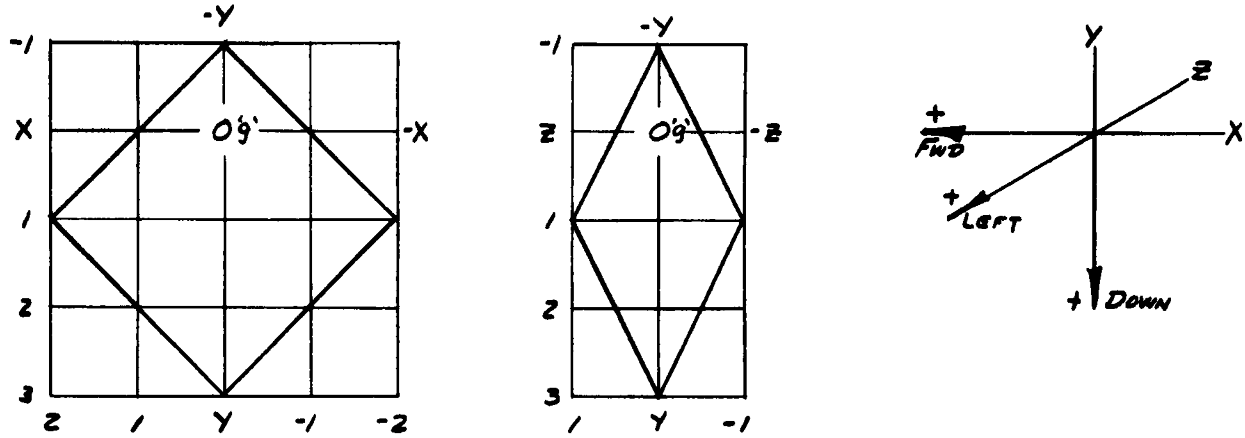
CONVERTING 1000 LB NET UPLIFT TO AXIAL COMPONENT:

$$1000\left(\frac{7.6}{3}\right) = 2530\ \text{LB}$$
REF. P.3

ADDITIONAL LOAD INCREASE BY ADDITION OF PITCH LOAD COMPONENT TO FORE & AFT COMPONENTS $= \frac{7900 + 2530}{7900} - 1 = 32\%$
(REF. P. 7)

EXAMINATION OF THE UNIT STRESS LEVELS AS CALCULATED ON PAGES 7, 8, AND 9 INDICATE THAT THIS 32% INCREASE IS NOT OF SERIOUS SIGNIFICANCE.

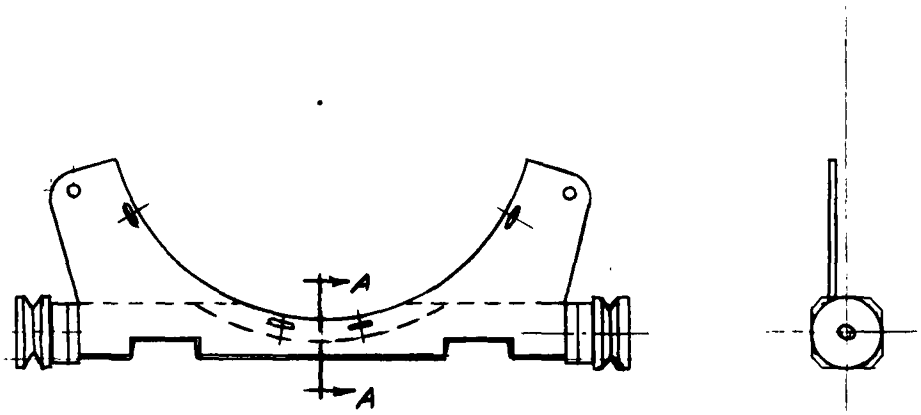
LOADING DIAGRAMS:



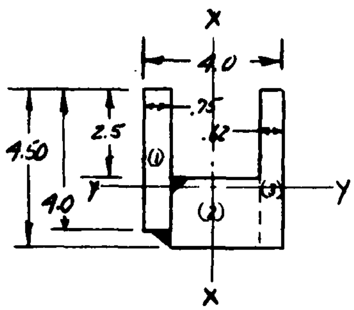
ALLOWABLE MOTOR LOADING:

1. ALLOWABLE COMPRESSION LOADING ON SKIRT = 1000 #/IN
2. ALLOWABLE MOMENT IN CHAMBER = 3.66 x 10⁶ in#
3. ALLOWABLE LOAD PER SKIRT BOLT = APPROX 8000#/BOLT

T-921167 'B'



SECT A-A



E	A	X	AX	h	Ah²	I_o
1	3.00	2.5	7.50	.78	1.82	4.00
2	5.26	1.0	5.26	.72	2.73	1.75
3	2.79	2.25	6.28	.43	.51	4.71
	11.05		19.04		5.06	10.46

$\bar{X} = \frac{19.04}{11.05} = 1.72$ IN

$I_{YY} = 5.06 + 10.46 = 15.52$ IN⁴

E	A	Y	AY	h	Ah²	I_o
1	3.00	3.62	10.86	1.61	7.78	.14
2	5.26	1.94	10.21	.05	.01	3.04
3	2.79	.32	.89	1.67	7.78	.09
	11.05		21.96		15.57	3.27

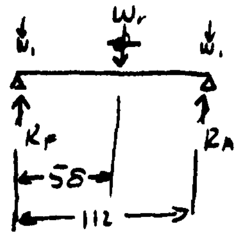
$\bar{Y} = \frac{21.96}{11.05} = 1.99$

$I_{XX} = 15.57 + 3.27 = 18.84$ IN⁴

SUBJECT Saddle - Transport - 44" Dia Engine
BY J. Cummins DATE 12/1/61 CHK. BY Wigg DATE 12/12/61

LOADING CONDITIONS:

1. 3 g down

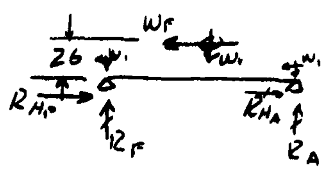


$W_v = 3(11800 + 1930) = (13730)(3) = 41190^{\#}$
$w_1 = (400^{\#})(3) = 1200^{\#}$ (saddle wt)

$R_A = \frac{(41190)(58)}{112} + 1200 = 21350 + 1200$
$= 22550^{\#} \quad = 11275\ ^{\#}/\text{wheel}$

$R_F = 41190 + (2)(1200) - 22550 = 43590 - 22550$
$= 21040^{\#} = 10520\ ^{\#}/\text{wheel}$

2. 1 g down, 2 g Fwd



$W_F = (2)(13730) = 27460^{\#}$
$W_v = 13730$
$w_{1_F} = (2)(400) = 800$
$w_{1_v} = 400^{\#}$

$R_{H_F} = 27460 + 800 = 28260^{\#} \quad = 14130\ ^{\#}/\text{wheel}$
$R_{H_A} = 800^{\#} \quad = 400^{\#}/\text{wheel}$

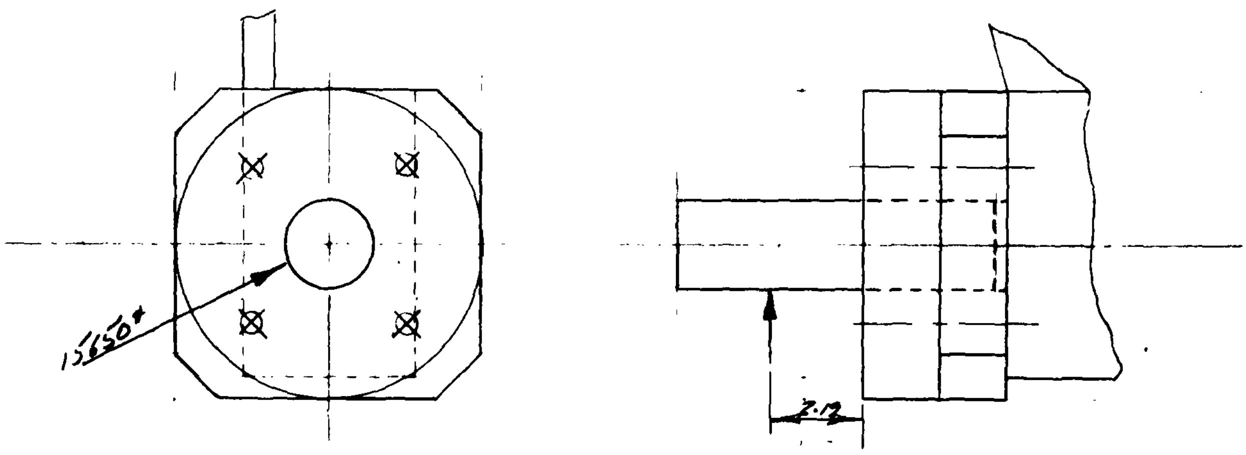
$R_F = \frac{(54)(13730)}{112} + 400 + \frac{(26)(27460)}{112}$
$= 6630 + 400 + 6380$
$= 13410^{\#} \quad = 6705\ ^{\#}/\text{wheel}$

$R_A = \frac{(58)(13730)}{112} + 400 - \frac{(26)(27460)}{112}$
$= 7120 + 400 - 6380$
$= 1140^{\#} \quad = 570\ ^{\#}/\text{wheel}$

LOAD CONDITION #2 (cont)

AXLE LOADING

MAX AXLE LOAD $= \left[(14130)^2 + (6705)^2\right]^{1/2} = \left[200 \times 10^6 + 45 \times 10^6\right]^{1/2}$
$= 15650^{\#}$



BENDING IN AXLE —

$M = (2.19)(15650) = 34300 \text{ in}^{\#}$

$S = .785 R^3 = (.785)(1)^3 = .785 \text{ in}^3$

$f_b = M/S = 34300/.785 = 43700 \text{ psi}$

$f_s = \frac{4V}{3A} = \frac{(4)(15650)}{(3)(.785)(2)^2} = 6650 \text{ psi}$

4340 STL HT 160,000 psi

M.S. HIGH

ATTACH BOLTS —

Max bolt Tension $= \frac{(14130)(3.94)}{(2)(3.54)} + \frac{(6705)(3.94)}{(2)(3.54)} = 7860 + 3730 = 11,600^{\#}$

$F_T = 24000^{\#}$

$f_t = (1.5)(11,600) = 17400^{\#}$

$MS = \frac{24000}{17400} - 1 =$ 1.38

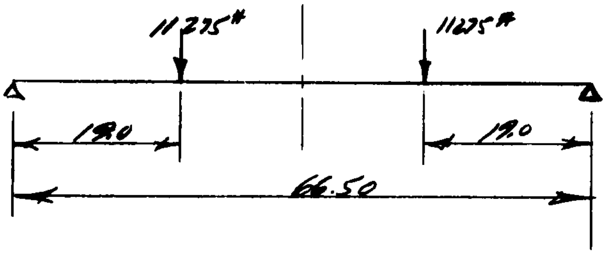
SUBJECT		DATE
SADDLE - TRANSPORT - 44" DIA ENGINE		12-7-61
		WORK ORDER 0380-22-905
BY T. CUMMINS	CHK. BY WIEG	DATE 12/12/61

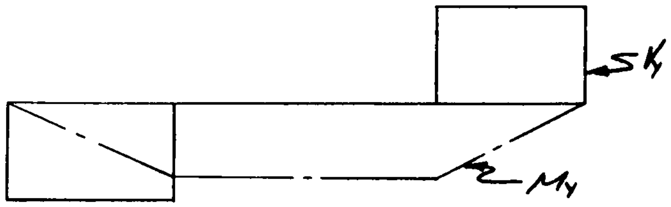
LOAD CONDITION #1 - 3 'g' down

BEAM LOADING —

MAX SADDLE LOAD = 22550# on aft saddle

DUE TO DEFORMATION OF SADDLES, AT MAXIMUM LOAD FACTOR THE LOADING WILL BE AS SHOWN:





$V_{MAX} = 11275^{\#}$
$M_{MAX} = 214500 \text{ in}^{\#}$

BENDING IN BEAM: at sect A-A.

$$f_{b_{MY(c)}} = \frac{M_y c}{I} = \frac{(214500)(2.78)}{15.52} = -38,400 \text{ psi}$$

$^*F_{Tu} = 63000$ psi
$F_{ty} = 46000$ psi

M.S. (yield)

$$= \frac{46000}{38000} - 1 = \underline{+.21}$$

* AVERAGE MECHANICAL PROPERTIES OF HOT ROLLED LOW CARBON STEEL — RYERSON DATA BOOK.

SUBJECT: SADDLE - TRANSPORT - 44" DIA ENGINE

DATE: 12-8-61

WORK ORDER: 0380-22-905

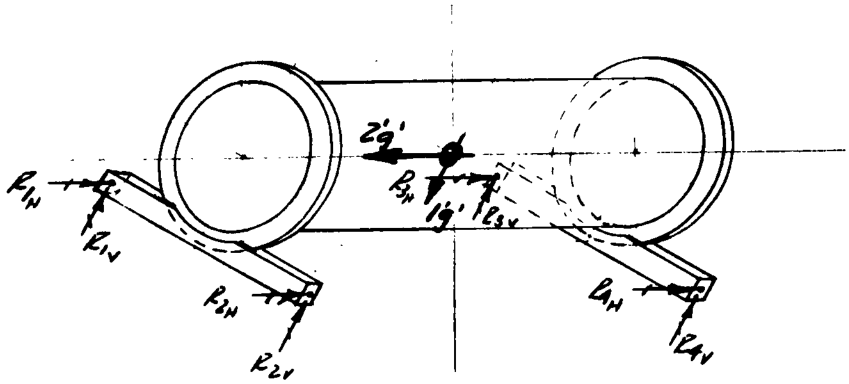
BY: T. CUMMINS

CHK. BY: WIEG

DATE: 12/12/61

LOAD COND #2

REVISED BEAM LOADING



MOTOR WT

(a) 2g' = (2)(13730) = 27460

(b) 1g' = (1)(13730) = 13730

SADDLE WT:

(a) 2g' = (2)(400) = 800 (each)

(b) 1g' = (1)(400) = 400 (each)

$$R_{1_H} = R_{2_H} = R_{3_H} = R_{4_H} = [27460 + (2)(800)](1/4) = 7265^{\#}$$

$$R_{1_V} = R_{2_V} = \left[\frac{(27460)(26)}{112} + \frac{(58)(13730)}{112} + 400\right]\frac{1}{2} = [6380 + 7120 + 400]\,\frac{1}{2}$$

$$= 6{,}950^{\#}$$

$$R_{3_V} = R_{4_V} = \left[\frac{(54)(13730)}{112} - \frac{(27460)(26)}{112} + 400\right]\frac{1}{2} = [6620 - 6380 + 400]\,\frac{1}{2}$$

$$= 320^{\#}$$

SUBJECT: SADDLE - TRANSPORT - 44" DIA ENGINE

DATE: 12-8-61

WORK ORDER: 0380-22-905

T. CUMMINS

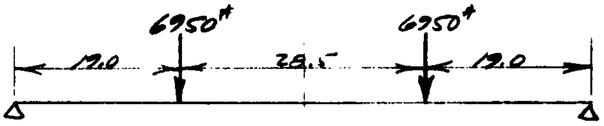
CHK. BY: WIEG

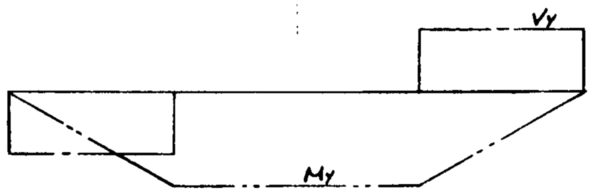
DATE: 12/12/61

LOAD COND #2

REVISED BEAM LOADING

1. VERTICAL LOADING





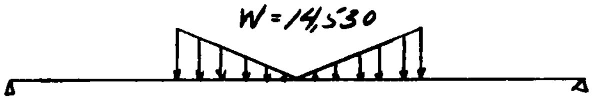
$V_{MAX} = 6950^{\#}$

$M_{MAX} = -132000\ in^{\#}$

bending in beam: (sect A-A)

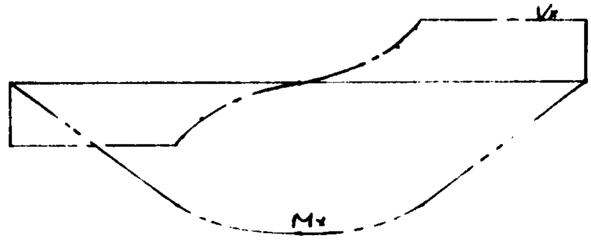
$$f_{b_{y\text{-}y(c)}} = \frac{M_y c}{I} = \frac{(-132000)(2.78)}{15.52} = -23650\ psi$$

2. HORIZONTAL LOADING



$R_1 = 7265^{\#}$

$R_2 = 7265^{\#}$



$V_{MAX} = 7265^{\#}$

$M_{MAX} = -172,400\ in^{\#}$

SUBJECT		DATE
SADDLE - TRANSPORT - 44" DIA ENGINE		12-11-61
		WORK ORDER 0380-22-905
BY T. CUMMINS	CHK. BY WIEG	DATE 12/12/61

LOAD COND #2

REVISED BEAM LOADING

2. HORIZONTAL LOADING (CONT)

bending in beam (sect A-A)

$$f_{b_{x-x}} = \frac{Mc}{I} = \frac{(172,400)(\pm 2.00)}{18.84} = \pm 18300 \text{ psi}$$

3. COMBINED BENDING

$$f_{b_{x-x}} + f_{b_{y-y}} = f_{b_t}$$

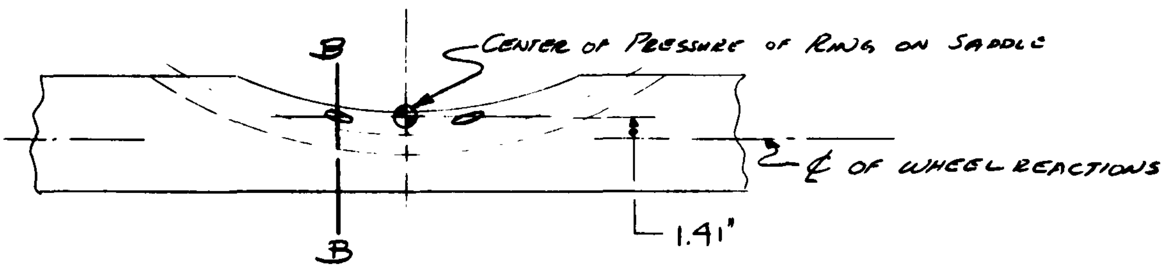
$$f_{b_t} = -18300 - 23650 = -41,950 \text{ psi}$$

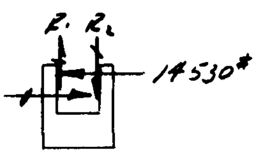
$$F_{b_{yield}} = 46,000 \quad \text{(REF pg 15)}$$

M.S. (yield)

$$= \frac{46000}{42000} - 1 = \qquad .09$$

ATTACH RINGS TO SADDLE:





SEC B-B

ROTATIONAL MOMENT IS REACTED BY 2-½" BOLTS (½ SOC HEAD CAP SCREWS)

$$R_1 = R_2 = \left(\frac{1}{2}\right)\left[\frac{(1.41)(14530)}{2.50}\right] = 4$$

$$F_s = 18500^{\#}$$

M.S. High

SUBJECT: SADDLE - TRANSPORT - 44" DIA ENGINE

DATE: 12-11-61

WORK ORDER: 0380-22-905

BY: T CUMMINS

CHK. BY: WIEG

DATE: 12/12/61

LOAD COND # 2

TORSIONAL STRESS (sect A A)

$T = (1.41)(14530) = 20500 \text{ in}\#$

$$f_s = \frac{T(3a + 1.8b)}{8a^2b^2} = \frac{20500\left[(3)(2) + (1.8)(1)\right]}{(8)(4)(1)}$$

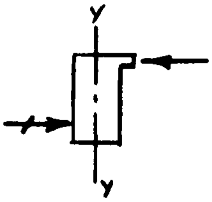
$$= \frac{(20500)(7.8)}{32}$$

$= 5000 \text{ psi}$

$F_S = 35000 \text{ psi}$

M.S. = High

RING LOADING (T-421079 HANDLING HARNESS)



$14580/24 = 610\#/\text{IN}$

$$I_{yy} = \frac{bh^3}{12} = \frac{(5.15)(2.5)^3}{12} = 6.6 \text{ in}^4$$

$$^{*}f_b = \frac{Mrc}{I} = \frac{(610)(4)(24.5)(1.25)}{6.6} = 11{,}300 \text{ psi}$$

$F_B = 63000$ (pg 7)

MS = High

* CONSERVATIVE ASSUMPTION OF RING LOADED ON FULL CIRCUMFERENCE.

10 X 10 QUADRILLE
AGC 3-067-008-1

Aerojet-General CORPORATION

SUBJECT: AGC Utility Van Proposed Aircraft Tiedown	DATE: 5/21/62
	WORK ORDER: 0625-26-006
BY: WIEG · CHK. BY: ALLEN	DATE: SEPT 6, 1962

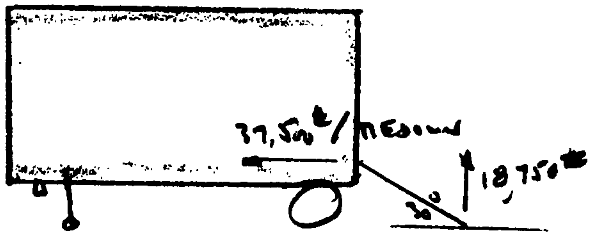
AGC UTILITY VAN

1) 10,000 LB CAPACITY TIEDOWNS AT 6 POINTS ON EACH SIDE OF TRAILER (AT ENDS OF CROSS CHANNELS) – THESE CHANNELS WILL NEED AN END-CONNECTION INTO THE SIDE EXTRUSIONS CAPABLE OF TRANSMITTING 7000 LB SHEAR (LIMIT LOAD)

VERT.

2) $\frac{3g}{2} = \frac{3(25000)}{2} = 37,500$ $\frac{37,500}{.866} = 43,300$ LB

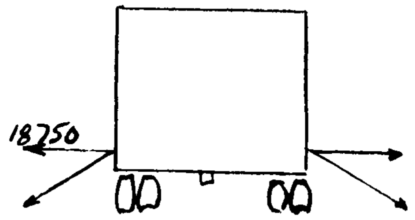
FORE & AFT



45,000 LB CAPACITY (LIMIT LOAD) TIEDOWNS AT 2 POINTS ON EACH END (LOCATION NOT DETERMINED YET)

ULT CAPACITY REQ'D: 1.5 (43,300) = 65,000 LB

3) LATERAL



SUBJECT: AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWN

DATE: 6/7/62

WORK ORDER: 0625-26-006

BY: WIEG

CHK. BY: ALLEN

DATE: SEPT 6, 1962

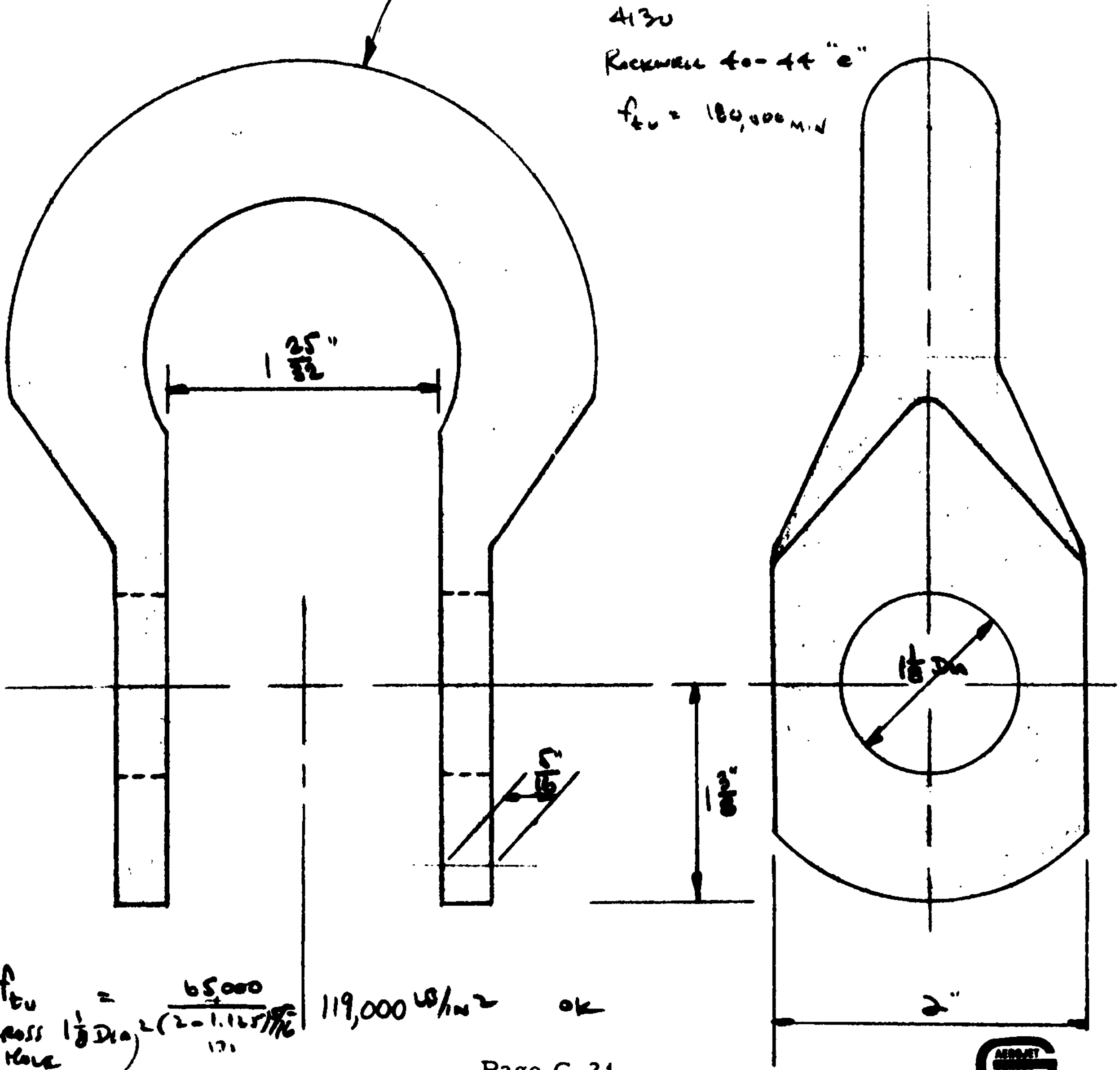
EASTERN ROTORCRAFT SHACKLE NO. SP-2225, CAPACITY 90,000 LB ULT.

THIS IS AN OFF-THE-SHELF ITEM

4130

ROCKWELL 40-44 "C"

f_{tu} = 180,000 MIN



f_{tu} (ACROSS $1\frac{1}{8}$ DIA HOLE) $= \dfrac{65,000}{2(2-1.125)\frac{5}{16}}$ | 119,000 LB/IN² OK

SUBJECT		DATE
AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWN		6/7/62
		WORK ORDER 0625-26-006
BY WIEG	CHK. BY ALLEN	DATE SEPT 6, 1962

DEVELOP 65,000 LB CONNECTION BETWEEN SHACKLE (SP-2225) & AGC VAN:

CHECK SHEAR VALUE OF $1\frac{1}{16}$" DIA PIN:

DOUBLE SHEAR

$$f_s = \frac{65\,000}{2(.8866)} = 36{,}700 \text{ LB/IN}^2$$

$$\text{REQ'D } f_{tu} = \frac{36{,}700}{.65} = 56{,}000 \text{ LB/IN}^2$$

HOT ROLLED MILD STEEL OK

CHECK BEARING LOAD ON SIDE MEMBERS:

$$f_b = \frac{65{,}000}{2(1.125)(.313)} = 92{,}000 \text{ LB/IN}^2$$

TOO HIGH FOR MILD STEEL

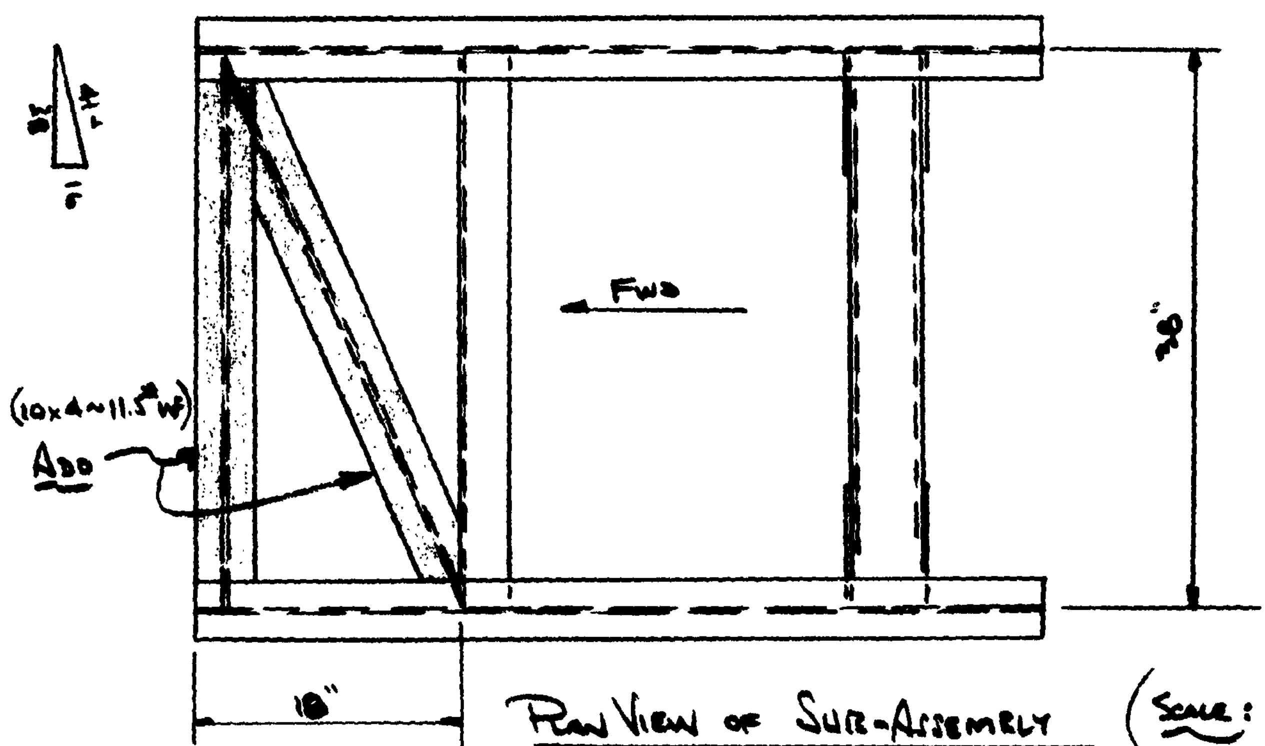
NEED 4130 OR SOME FORM OF COLD-ROLLED STEEL

SUBJECT		DATE
AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWNS		JUNE 14, 1962
		WORK ORDER 0625-26-006
BY WIEG	CHK. BY ALLEN	DATE SEPT 6, 1962

INVESTIGATE LOAD PATH OF LATERAL TIEDOWN FORCES:

(REF: UTILITY TRAILER MFG CO. DRAWING NO CB-1084)

MAYNARD LAGASSEE PROPOSES ATTACHING TIEDOWN FITTINGS TO THE FORWARD END OF 10"~11.5# BEAMS, WHICH ARE THE MAJOR COMPONENTS OF THE AGC VAN AFT SUB-ASSEMBLY.
THIS IS FINE, IF THE SUB-ASSEMBLY IS STRENGTHENED WITH ADDITIONAL SHEAR-RESISTING COMPONENTS, SINCE THE 10"~11.5# BEAMS CAN NOT RESIST UNIT TIEDOWN-LOAD BENDING MOMENTS ABOUT THE Y-Y AXIS.



PLAN VIEW OF SUB-ASSEMBLY (SCALE: 1" = 1'-0")
(AFT END OF TRAILER)

SUBJECT		DATE
AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWNS		JUNE 14, 1962
		WORK ORDER 0625-26-006
BY WIEG	CHK. BY ALLEN	DATE SEPT 6, 1962

INVESTIGATE 10" x 4" WF FOR ADEQUACY AS A COLUMN:

HORIZONTAL LOAD COMPONENT = $\frac{1}{2}$ FORE & AFT LOAD COMPONENT (SEE PAREA)

$$= \tfrac{1}{2}(37{,}500) = 18{,}750 \text{ LB}$$

AXIAL LOAD COMPONENT IN DIAGONAL COMPRESSION MEMBER = $18{,}750\left(\frac{41}{38}\right) = 20{,}200$ LB

$\frac{l}{r} = \frac{41}{.79} = 52$; AISC $F_c = 15{,}600$ LB/IN² (P.209)

ALLOWABLE AXIAL LOAD = $15{,}600\,(\underbrace{3.39}_{\text{AREA}}) = 52{,}800$ LB

D.F. = $\frac{52{,}800}{20{,}200} > 2$, OK

AEROJET GENERAL

10 X 10 QUADRILLE
AGC 3-067-008-1

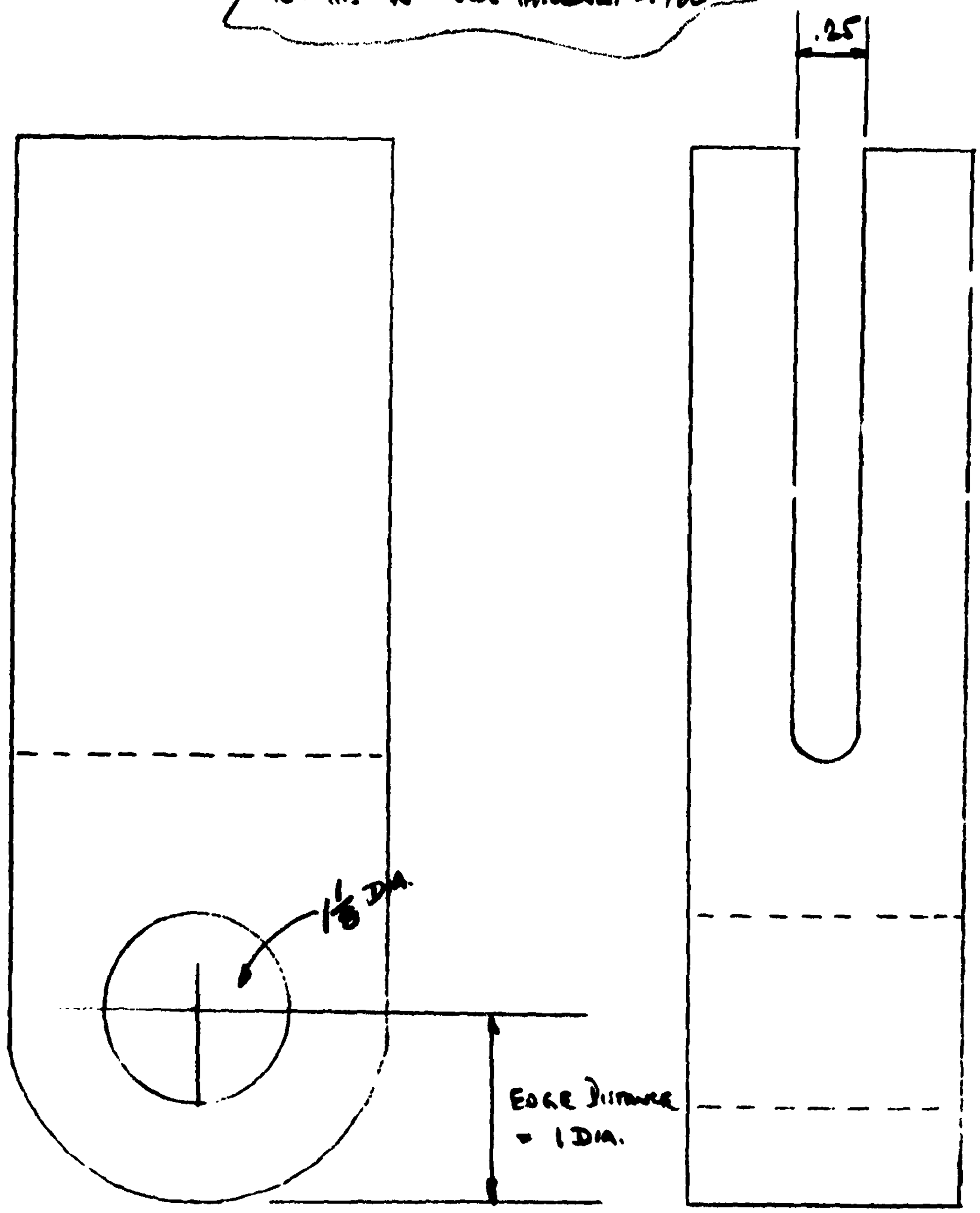
Aerojet-General CORPORATION

SUBJECT	DATE
TIEDOWN CONFIGURATION PROPOSAL	
	WORK ORDER 0625-26-006

BY	CHK BY	DATE
LAGASSEE	ALLEN	SEPT 6, 196[illegible]

TIEDOWNS FOR FORE & AFT LOADS

10" ~ 11.5# WF WEB THICKNESS = .180



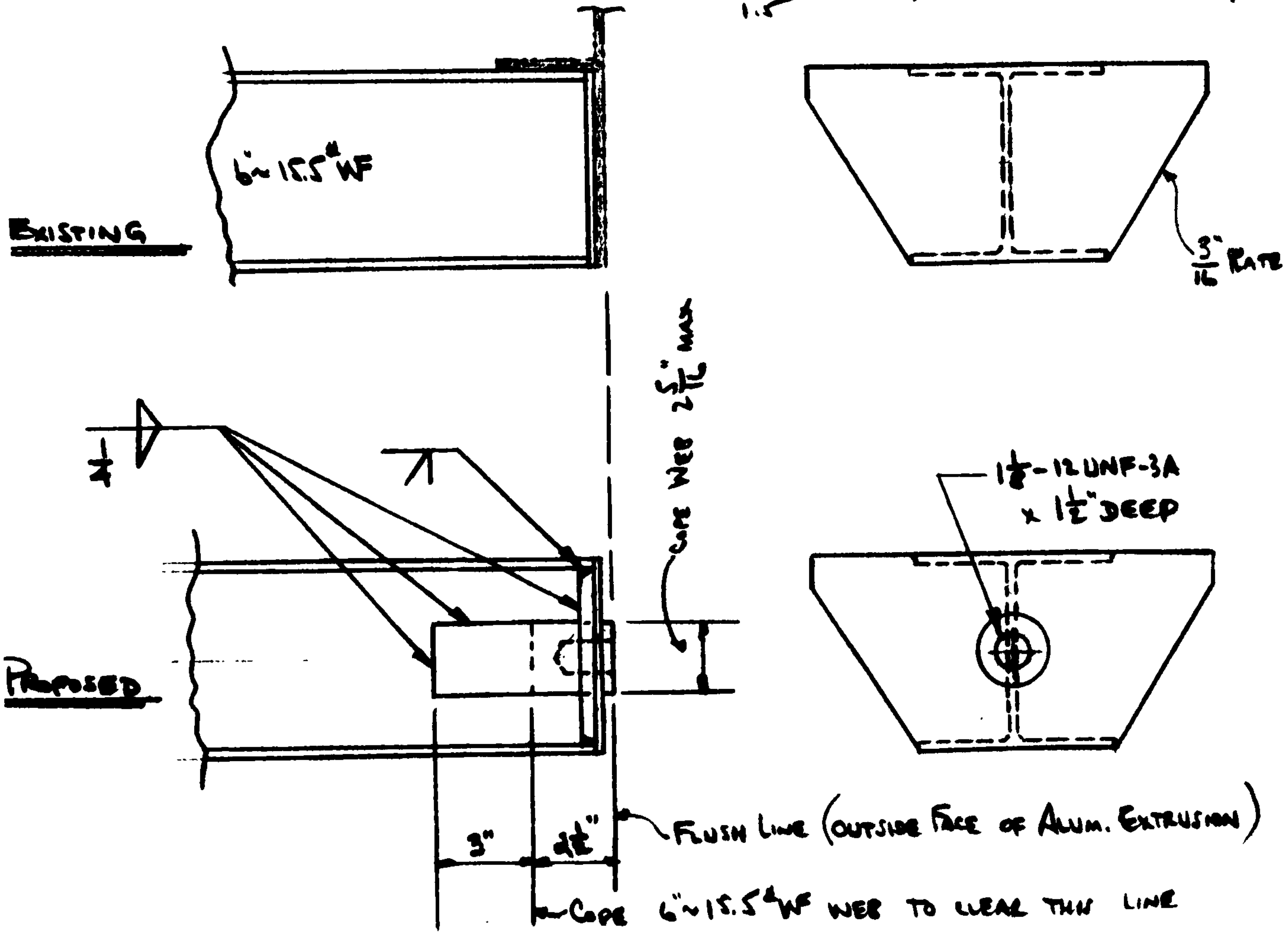
SUBJECT		DATE
AGC UTILITY VAN PROPOSED AIRCRAFT TIEDOWNS		JULY 5, 1962
		WORK ORDER: 0625-26-006
BY: WIEG	CHK. BY: ALLEN	DATE: SEPT 6, 1962

CLEARANCE REQUIREMENTS BENEATH THE VAN AND AT THE SIDES OF THE VAN NECESSITATE FLUSH SIDE CONNECTIONS FOR LATERAL TIEDOWN AT THE FRONT OF THE VAN. (PER DISCUSSION W/ JACK CREWS, DEPT 5421)

LATERAL LOAD PER FITTING = $\frac{1.5 g's}{2}$ = .75(25,000) = 18,750 LB/FITTING

EASTERN ROTORCRAFT CATALOG PART NO. SP-3079 HAS AN ULTIMATE CAPACITY OF 35,250 LB

APPLYING DESIGN FACTOR OF 1.5,
ALLOWABLE LOAD ON PART SP-3079 = $\frac{35,250}{1.5}$ = 23,500 LB > 18,750 SO OK.



SUBJECT: AGC UTILITY VAN - PROPOSED AIRCRAFT TIEDOWNS
DATE: JULY 6, 1962
WORK ORDER: 0625-26-006
BY: WIEG
CHK. BY: ALLEN
DATE: SEPT 6, 1962

DETERMINE MINIMUM MILD STEEL ROUND WHICH WILL DEVELOP THE CAPACITY OF FITTING SP-3079 (35,000 LB)

FOR MILD STEEL, ALLOWABLE $F_{su} = \frac{55000}{5} = 11{,}000$ LB/IN²

DESIGN FACTOR

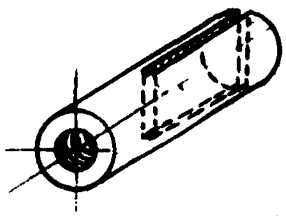
REQ'D CROSS-SECTIONAL AREA $= \frac{35{,}000}{11{,}000} = 3.18$ IN²

AREA OF $1\frac{1}{8}$" ROD = .99 IN²

GROSS AREA REQ'D : 4.17 IN²

$A_{2\frac{1}{4}\phi} = 3.98$ IN² $\quad \frac{4.17}{3.98} = 1.047$

$A_{2\frac{1}{2}\phi} = 4.91$ IN²



$2\frac{1}{2}\phi$ IS ADEQUATE

DETERMINE REQ'D LENGTH OF WELD FOR ATTACHMENT TO 6" WF WEB:

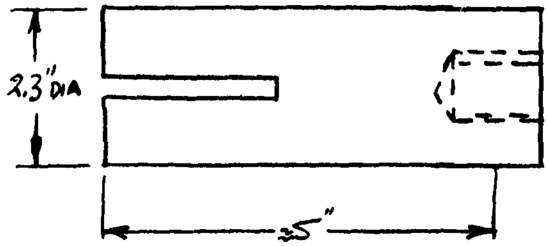
AT ALLOWABLE WELD LOAD OF 2400 LB/INCH (1/4" FILLET)

WELD LENGTH REQ'D $= \frac{35000}{2400} = 14.6$ LIN. INCHES

USE 3" PROJECTION BEYOND COPE LINE

SUBJECT	DATE
AGC UTILITY VAN - PROPOSED AIRCRAFT TIEDOWNS	Sept 6, 1962
	WORK ORDER 0625-26-006

BY	CHK BY	DATE
ALLEN	Wieg	



LENGTH OF WELD = 2 (5 + 5 + 2.3) = 24.6"

FROM Pg. 27, ONLY 14.6" ARE NEEDED
SO THIS IS O.K..

SUBJECT: TRANSPORT SADDLE - 44" FW ENGINE (REF: AGC DWG T-421194)

DATE: 8-16-62

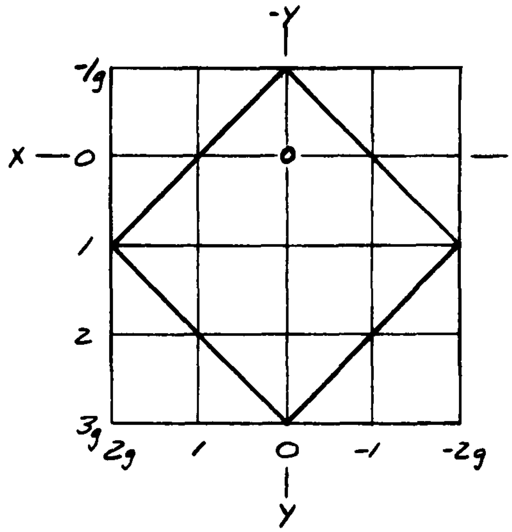
WORK ORDER: 0625-26-006

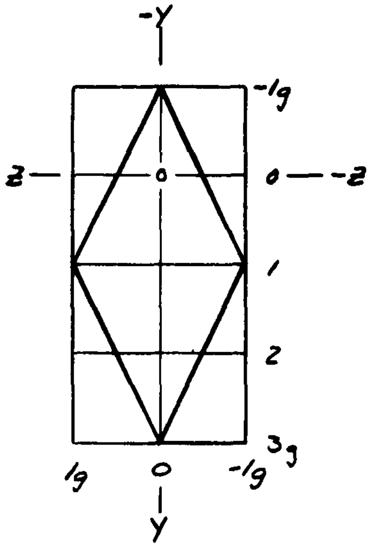
BY: T. CUMMINS

CHK. BY: R.F. ALLEN

DATE: 9-10-62

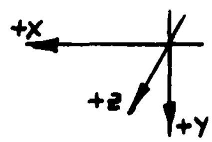
LIMIT LOAD ENVELOPE:





SIGN CONVENTION:

X = POS. FW'D
Y = POS. DOWN
Z = POS. LEFT



WEIGHT SUMMARY

ENGINE = 11,800#

HANDLING CONTAINER = 1930#

FWD RING = 610
AFT RING = 570
RAILS = 750
} 985# @ FWD END
945# @ AFT END

TRANSPORT SADDLES ≈ 250# EACH

$\Sigma = 14{,}230$#

LOAD CONDITIONS - 3 CONDITIONS WILL BE INVESTIGATED.

COND 1 - 3 'g' DOWN

COND 2 - 2 'g' FWD & 1 'g' DOWN

COND 3 - 1 'g' SIDE & 1 'g' DOWN

SUBJECT: TRANSPORT SADDLE - 44" FW ENGINE

DATE: 8-16-62

WORK ORDER: 0625-26-006

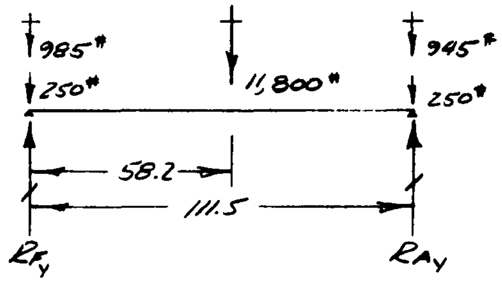
BY: T. CUMMINS

CHK. BY: R.T. ALLEN

DATE: 9-10-62

LOAD CONDITIONS (LIMIT LOADS)

COND 1 - 3g DOWN



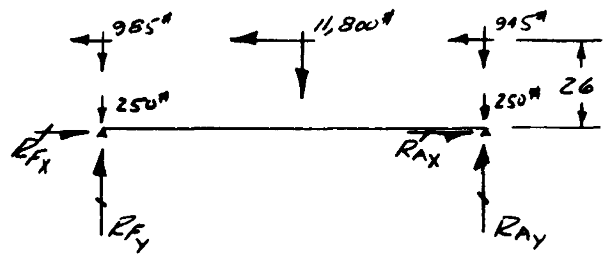
$$R_{F_y} = \frac{(3)(11800)(53.3)}{111.5} + (3)(985+250) = 16920 + 3705$$

$$= 20{,}625^\# = 10{,}315^\#/\text{WHEEL}$$

$$R_{A_y} = (3)(11800) - 16920 + (3)(945+250) = 18480 + 3585$$

$$= 22{,}065^\# = 11{,}035^\#/\text{WHEEL}$$

COND 2 - 2g FWD & 1g DOWN



$$R_{F_x} = \frac{(2)(11800)}{2} + (2)(985) = 11800 + 1970$$

$$= 13{,}770^\# = 6{,}885^\#/\text{WHEEL}$$

$$R_{A_x} = \frac{(2)(11800)}{2} + (2)(945) = 11800 + 1890$$

$$= 13{,}690^\# = 6{,}845^\#/\text{WHEEL}$$

$$R_{F_y} = 985 + 250 + \frac{(11800)(53.3)}{111.5} + \frac{(2)(11800+985+945)(26)}{111.5} = \quad 6405$$

$$= 13{,}280^\# = 6{,}640^\#/\text{WHEEL}$$

$$R_{A_y} = 945 + 250 + \frac{(11800)(58.2)}{111.5} - \frac{(2)(11800+985+945)(26)}{111.5} = 7355 - 6405$$

$$= 950^\# = 475^\#/\text{WHEEL}$$

SUBJECT: TRANSPORT SADDLE - 44" FW ENGINE

DATE: 8-17-62

WORK ORDER: 0625-26-006

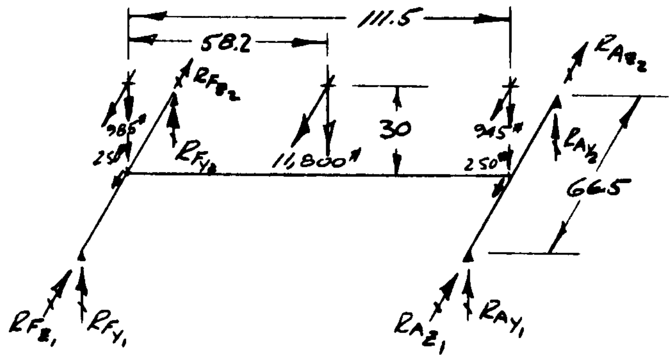
BY: T. CUMMINS

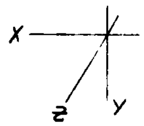
CHK. BY: R.F. ALLEN

DATE: 9-10-62

LOAD CONDITIONS - (LIMIT LOADS), (CONT)

COND 3 - 1 'g' SIDE & 1 'g' DOWN





$$R_{F_{z_1}} = R_{F_{z_2}} = \left[\frac{(11800)(53.3)}{111.5} + 985 + 250\right]\tfrac{1}{2} = \tfrac{1}{2}(5640 + 985 + 250)$$
$$= 3440\#$$

$$R_{A_{z_1}} = R_{A_{z_2}} = \left[11800 - 5640 + 945 + 250\right]\tfrac{1}{2} = \tfrac{1}{2}(6160 + 1195)$$
$$= 3680\#$$

$$R_{F_{y_1}} = (\tfrac{1}{2})(5640 + 985 + 250) + \frac{(30)(5640 + 985)}{66.5} = 3440 + 2990$$
$$= 6430\#$$

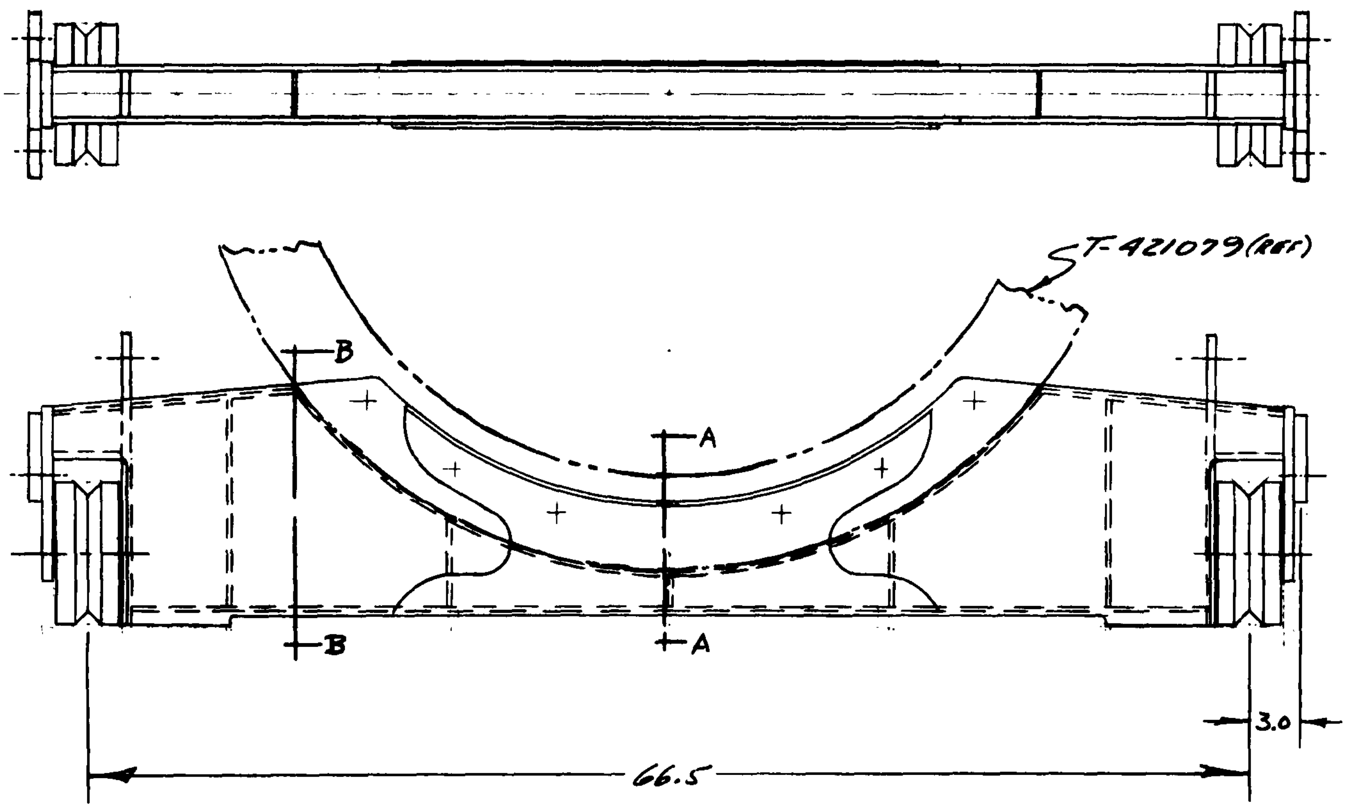
$$R_{F_{y_2}} = 3440 - 2990$$
$$= 450\#$$

$$R_{A_{y_1}} = (\tfrac{1}{2})(6160 + 945 + 250) + \frac{(30)(6160 + 945)}{66.5} = 3680 + 3210$$
$$= 6890\#$$

$$R_{A_{y_2}} = 3680 - 3210$$
$$= 470\#$$

SUBJECT		DATE
TRANSPORT SADDLE - 44" FW ENGINE		8-17-62
		WORK ORDER 0635-26-006
BY T. CUMMINS	CHK. BY R.F. ALLEN	DATE 9-10-62

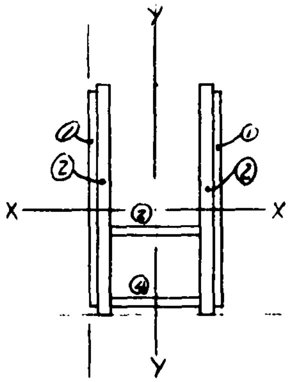
AGC D'WG T-421914



SUBJECT: TRANSPORT SADDLE- 44" FW ENGINE
DATE: 8-22-62
WORK ORDER: 0625-26-006
BY: T. CUMMINS
CHK BY: R.F. ALLEN
DATE: 9-10-62

SECTION PROPERTIES (REF PG 33)

SECT A-A



E	A	Y	AY	h_y	Ah_y^2	I_{o_x}
1	3.00	3.30	9.90	.29	.25	9.00
2	4.88	3.25	15.87	.24	.28	17.16
3	.64	2.38	1.52	.63	.25	–
4	.64	.37	.24	2.64	4.46	–
	$9.16\,in^2$		27.53		5.24	26.16

$$\bar{Y} = \frac{27.53}{9.16} = 3.01\,in$$

$$I_{xx} = 5.24 + 26.16 = 31.40\,in^4$$

$C_{Top} = 6.50 - 3.01 = 3.49\,in$

$C_{Bot} = 3.01\,in$

$$I_{y\text{-}y} = \Sigma A h_x^2 + \Sigma I_{oy}$$

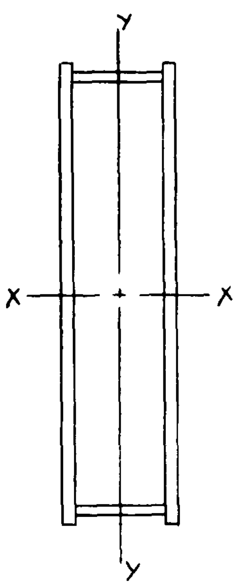
$$= (2)(1.50)(1.78)^2 + (2)(2.44)(1.47)^2 + \frac{(.5)(2.56)^3}{12} + \frac{(2)(.62)^3(6)}{12}$$

$$= 10.03 + 10.54 + .70 + .24$$

$$= 21.51\,in^3$$

$c = 1.91\,in$

SECT B-B



$$AREA = (2)(.375)(13) + (2)(.25)(2.56) = 9.75 + 1.28 = 11.03\,in^2$$

$$I_{x\text{-}x} = \Sigma A h^2 + \Sigma I_o$$

$$= (1.28)(6.12)^2 + (2)(.38)(13)^3/12$$

$$= 47.9 + 117.1$$

$$= 165\,in^4 \qquad c = 6.5$$

$$I_{y\text{-}y} = \Sigma A h^2 + \Sigma I_o$$

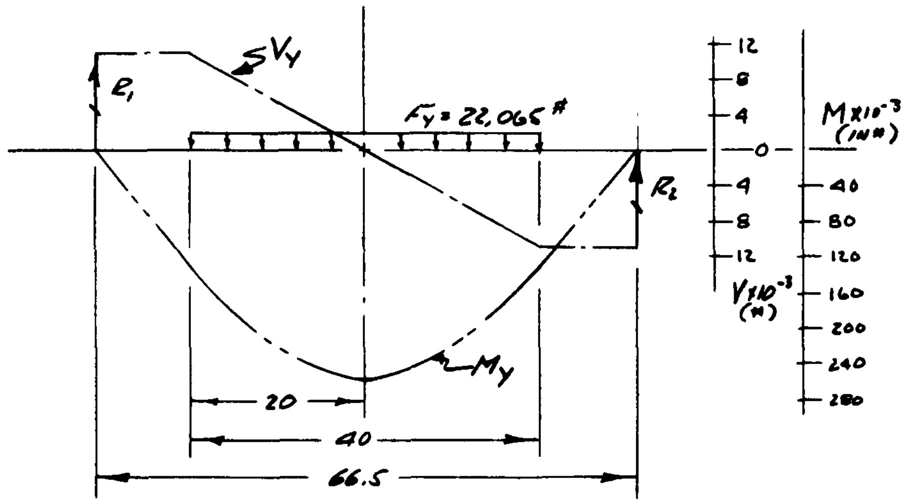
$$= (9.75)(1.47)^2 + (5)(2.56)^3/12 + (2)(13)(.38)^3/12$$

$$= 21.1 + .7 + .1$$

$$= 21.9\,in^4 \qquad c = 1.66$$

SUBJECT		DATE 8-22-62
TRANSPORT SADDLE - 44" FW ENGINE		WORK ORDER 0625-26-006
BY T. CUMMINS	CHK. BY R.F. ALLEN	DATE 9-10-62

CONDITION 1 MAX VERTICAL LOAD



$R_1 = R_2 = (\frac{1}{2})(22065) = 11{,}035^{\#}$

$M_{MAX} = (\frac{22065}{2})(13.25 + \frac{40}{4}) = (11035)(23.25) = 257{,}500 \text{ in}^{\#}$

BENDING IN SECT A-A (REF PG 32)

$M = 257500$

$f_b = \frac{Mc}{I} = \frac{(257500)(-3.49)}{31.4} = -28{,}600 \text{ psi}$

$F_{cy} = 36{,}000 \text{ psi}$

$M.S.(\text{yield}) = \frac{36000}{28600} - 1 \qquad = +.26$

SUBJECT: TRANSPORT SADDLE - 44" FW ENGINE

DATE: 8-24-62

WORK ORDER: 0625-26-006

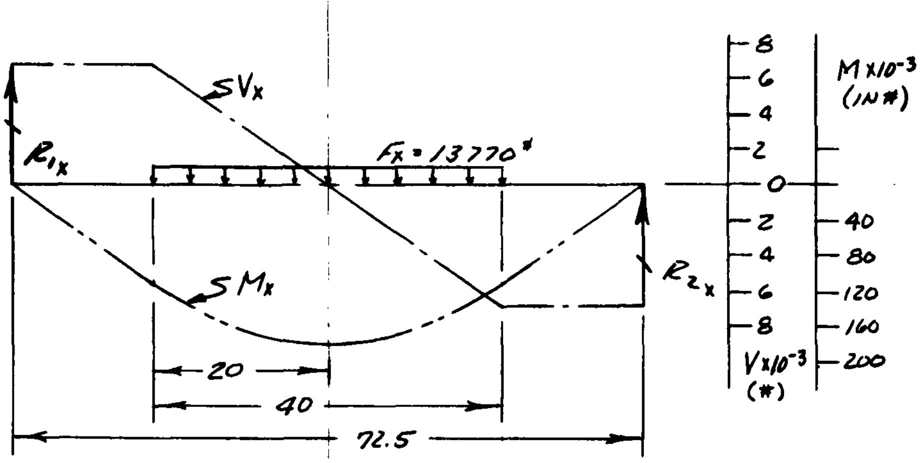
BY: T. CUMMINS

CHK. BY: R.F. ALLEN

DATE: 9-10-62

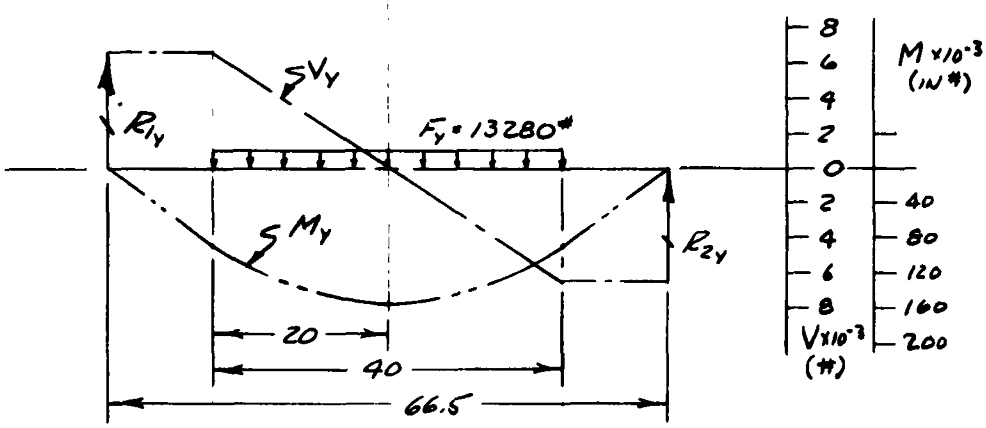
CONDITION 2 - MAX COMBINED LOADING

AXIAL



$R_{1x} = R_{2x} = (\frac{1}{2})(13770) = 6885^{\#}$

$M_{MAX} = (\frac{13770}{2})(16.25 + \frac{40}{4}) = (6885)(26.25) = 181,000 \text{ in}^{\#}$



$R_{1Y} = R_{2Y} = (\frac{1}{2})(13280) = 6640^{\#}$

$M_{MAX} = (\frac{13280}{2})(13.25 + \frac{40}{4}) = (6640)(23.25) = 154,000 \text{ in}^{\#}$

SUBJECT	DATE
TRANSPORT SADDLE - 44" FW ENGINE	8-24-62
	WORK ORDER 0625-26-006
BY T. CUMMINS	CHK. BY R. F. ALLEN — DATE 9-10-62

CONDITION 2 - (CONT)

BENDING IN SECTION A-A (REF PG 32)

$M_y = 154000 \text{ in}^{\#}$

$M_x = 181,000 \text{ in}^{\#}$

$$f_{b_x} = \frac{M_x c}{I_y} = \frac{(181000)(-1.91)}{21.51} = -16,100 \text{ psi}$$

$$f_{b_y} = \frac{M_y c}{I_x} = \frac{(154000)(-3.49)}{31.40} = -17,100 \text{ psi}$$

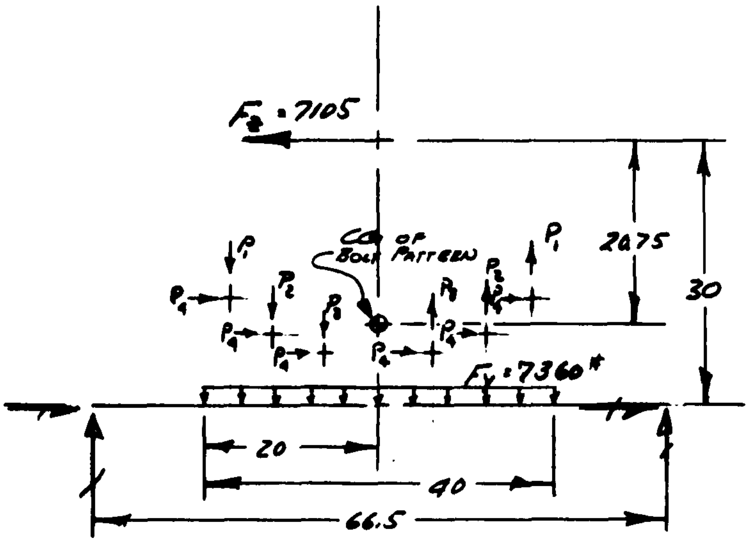
$$f_{b_{tot}} = -16100 - 17100 = -33200 \text{ psi}$$

$F_{cy} = -36,000 \text{ psi}$

$$\text{M.S. (yield)} = \frac{36000}{33200} - 1 = \underline{+.08}$$

CONDITION 3 - MAX SIDE LOAD

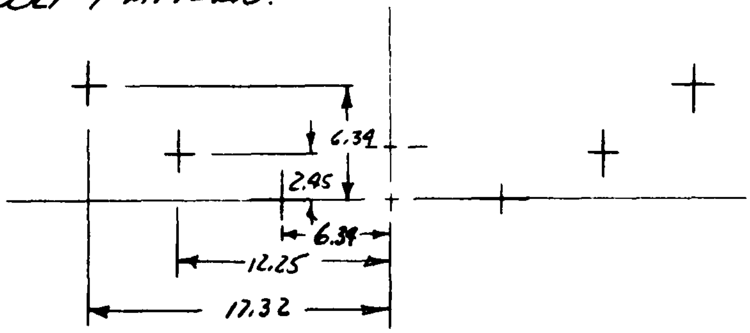
ASSUME BOLTS HOLDING SADDLE TO RING TRANSFER SIDE LOAD & COUPLE.



SUBJECT	DATE
TRANSPORT SADDLE - 44" FW ENGINE	8-27-62
	WORK ORDER 0625-26-006
BY T. CUMMINS / CHK. BY R.F. ALLEN	DATE 9-10-62

CONDITION 3 - (CONT)

BOLT PATTERN:



BOLT #	X	Y
1	-17.32	6.34
2	-12.25	2.45
3	-6.34	0
4	6.34	0
5	12.25	2.45
6	17.32	6.34
Σ	0	17.58

$\bar{Y} = \frac{17.58}{6} = 2.93$

$\bar{X} = 0$

$I_{BP} = \Sigma r^2 \approx (2)(17.32)^2 + (2)(12.25)^2 + (2)(6.34)^2$
$= 600 + 300 + 80$
$= 980 \text{ in}^2$

BOLT LOADS:

$M = (7105)(20.75) = 147,700 \text{ in}^\#$

$P_1 = \left(\frac{147700}{980}\right)(17.32) = 2610^\#$

$P_2 = \left(\frac{147700}{980}\right)(12.25) = 1845^\#$

$P_3 = \left(\frac{147700}{980}\right)(6.34) = 955^\#$

$P_4 = 7105/6 = 1185^\#$

MAX BOLT LOAD $= [(1185)^2 + (2610)^2]^{1/2} = [8.215 \times 10^6]^{1/2} = 2870^\#$

1/2 HEX HEAD SCREW $F_s = (35000)(.785)(.406)^2 = 4600^\#$

$MS \text{ (ULTIMATE)} = \frac{4600}{(1.5)(2870)} - 1 =$ 1.07

SUBJECT: TRANSPORT SADDLE - 44" FW ENGINE

DATE: 8-28-62

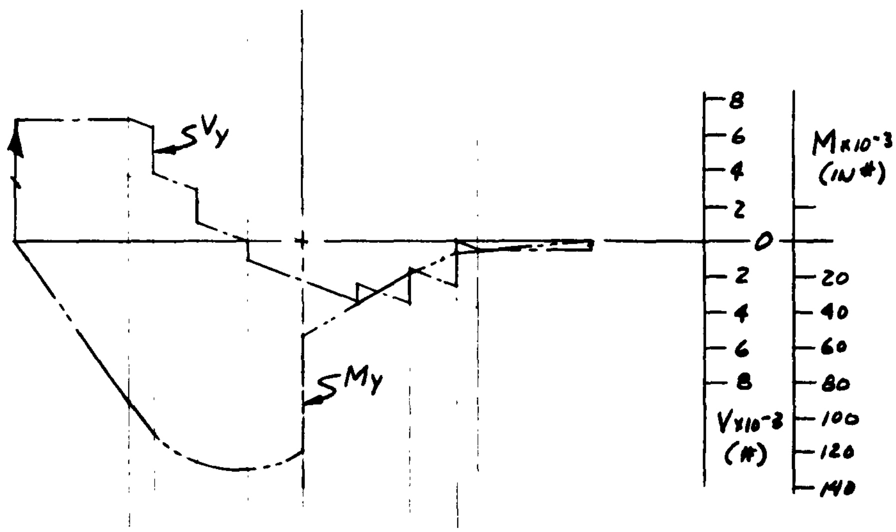
WORK ORDER: 0625-26-006

BY: T. CUMMINS

CHK. BY: R.F. ALLEN

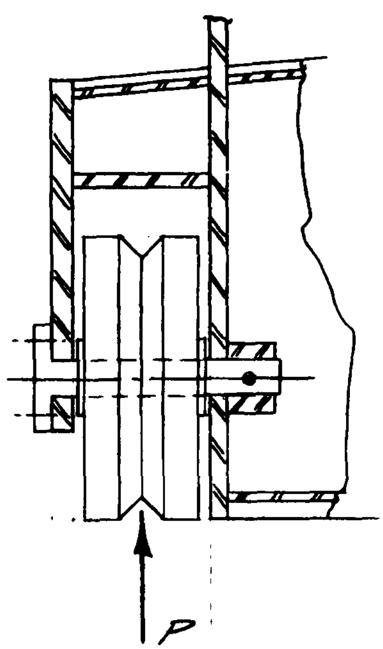
DATE: 9-10-62

CONDITION 3 - (CONT)



BENDING IN SADDLE NOT CRITICAL FOR THIS COND

MAX WHEEL LOAD



P_{MAX} (COND 1) = 11,035#

WHEEL IS "AEROL" V-GROOVE #3001
1 'g' LOAD RATING = 8000#

AXLE -

1" STEEL ROD

$F_s = (35000)(.785)(1)^2 = 29000^{\#}$

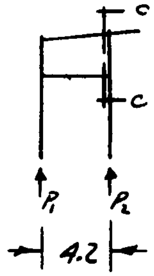
$f_s = (\frac{1}{2})(11035) = 5520^{\#}$

$MS = \frac{29000}{5520} - 1 = \underline{HIGH}$

SUBJECT		DATE 8-28-62
TRANSPORT SADDLE - 44" FW ENGINE		WORK ORDER 0625-26-006
BY T. CUMMINS	CHK. BY R.F. ALLEN	DATE 9-10-62

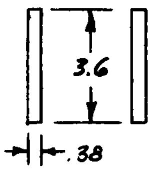
MAX WHEEL LOAD (CONT)

WHEEL SUPPORT -



$P_1 = P_2 = 5520^{\#}$

SECTION C-C
(USE ONLY SIDE PLATES TO CARRY LOAD)



$S = \frac{(2)(.38)(3.6)^2}{6} = 1.62 \text{ IN}^3$

$M = 4.2 P_1 = (4.2)(5520) = 23,200 \text{ in}^{\#}$

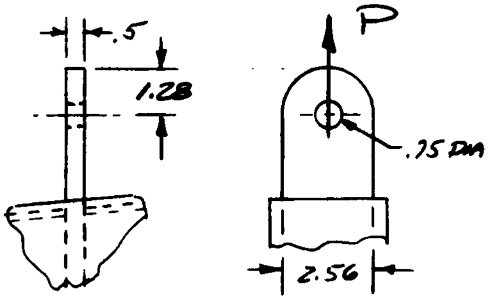
$f_b = M/S = 23200/1.62 = 14,300 \text{ psi}$

$f_s = \frac{1.5V}{ab} = \frac{(1.5)(5520)}{(3.6)(.38)} = 6060 \text{ psi}$

$F_{cy} = 36,000 \text{ psi}$

$M\,S\,(\text{YIELD}) = \frac{36000}{14300} - 1 \qquad = +\text{HIGH}$

LIFTING LUG



DESIGN FACTOR = 5 (ULTIMATE)

$P_{DES} = (\frac{5}{3})(11035)^{*} = 18,400^{\#}$

SHEAR OUT

$F_S = (2)(\frac{1}{2})(.95)(35000) = 33200^{\#}$

TENSION

$F_T = (.75)(2.56 - .75)(\frac{1}{2})(55000) = 49500^{\#}$

$M.S. = \frac{33200}{18400} - 1 = +.80$

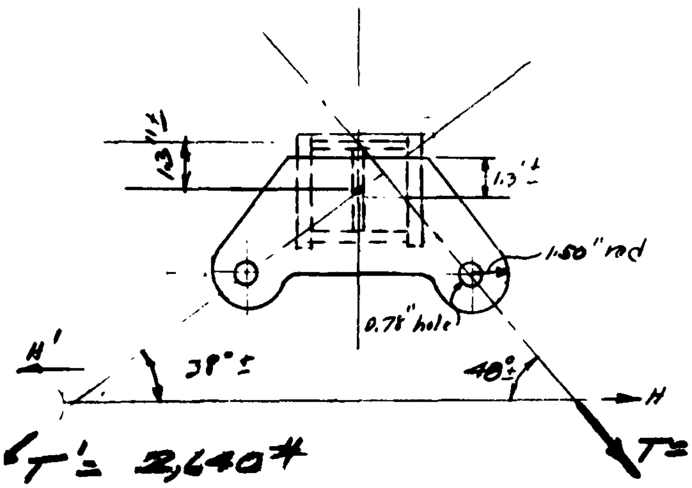
SUBJECT		DATE 5-8-62
Transport Saddle 44" F.W. Engine		WORK ORDER 0625-98-012
BY Schultz	CHK. BY Wieg	DATE 8-28-62

This change was required in order to strengthen saddle for tie down loads in the "Utility Van."

Max. H due to fore & aft 2G

$$H = \frac{(13000)(2)}{4} = 6500^{\#}$$

$$T = \frac{6500}{\cos 46^\circ} = \frac{6500}{0.670} = 9700^{\#}$$



Torsion applied box section

$$\text{Torque} = (9700)(1.3) = 12{,}600^{\text{in-\#}}$$

$$s = \frac{T}{2t(a-t)(b-t_1)} = \frac{12600}{(2)(.375)(2.625)^2}$$

$= 2850$ psi

low ∴ ok

$T' = 2{,}640^{\#}$

vert load

$$T' = \frac{3250}{\sin 38°(2)} = \frac{3250}{(.616)(2)} = 2640^{\#}$$

Max Bending!

$$M = (9700)(5) = 48{,}500^{\text{in-\#}}$$

$$I = \frac{(4)(5)^3}{12} - \frac{(3.25)(2.25)^3}{12} = 5.92 \text{ in}^4 \qquad z = \frac{5.92}{1.5} = 3.95 \text{ in}^3$$

$$f_b = \frac{48500}{3.95} = 12{,}300 \text{ psi} \quad \text{low ∴ OK.}$$

Check Lugs;

$M = KPr$ $\quad K = 0.28 \quad P = T = 9{,}700 \quad r = 0.70"$

$$M = (0.28)(9{,}700)(.70) = 1900^{\text{in-\#}}$$

(curved beam factor)

.75" × .61"

$$Z = \frac{(0.75)(.61)^2}{6} = 0.0466 \text{ in}^3 \qquad f_b = \frac{(1.5)(1900)}{(0.0466)} = 61{,}000 \text{ psi}$$

too high

Try an edge distance of 1.5"

.75 × 1.11

$$r = 0.93 \qquad M = \frac{(1900)(.93)}{(.70)} = 2520^{\text{in-\#}}$$

$$z = \frac{(.75)(1.11)^2}{6} = 0.154 \text{ in}^3 \qquad f_b = \frac{(61{,}000)(.0466)}{0.154} = 18{,}500 \text{ psi}$$

Des. Factor = 3.25:1 ok

Use 1.5" Edge Dist.

SUBJECT: Transport Saddle 44" F.W. Engine

DATE: 5-8-62

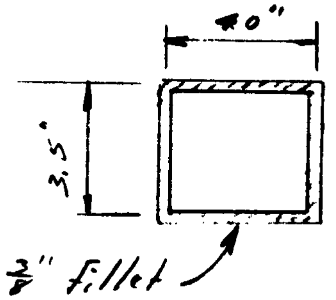
WORK ORDER: 0625-98-012

BY: Schultz

CHK. BY: Wieg

DATE: 8-28-62

Check Welds



Direct Shear = 9700#

$T = 12{,}600$ in-#

throat depth = $(.707)(.375) = 0.265" = t = t_1$

torsional shear ~

$$s = \frac{T}{2t(a-t)(b-t_1)} = \frac{9700}{(2)(0.265)(2.235)(3.735)} = \underline{2200\ psi}$$

direct shear ~

$$\frac{P}{A} = \frac{9700}{(15)(.265)} = \underline{2430\ psi}$$

Total Shear = **4630 psi**

Des. Factor = $\frac{35}{4.6}$ = 7.6:1 OK

SUBJECT: Transport Saddle 44" F.W. Engine

DATE: 8-17-62

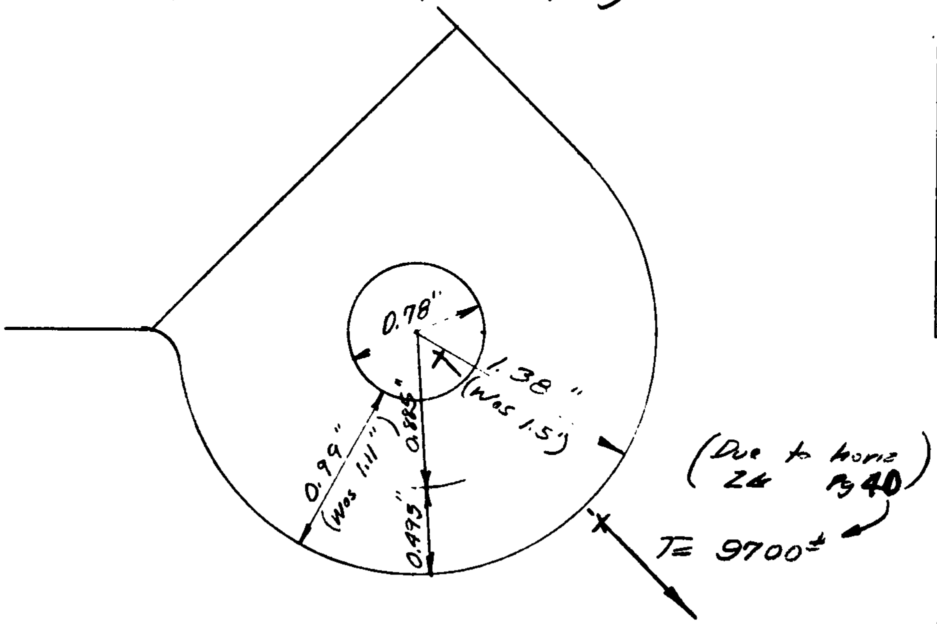
WORK ORDER:

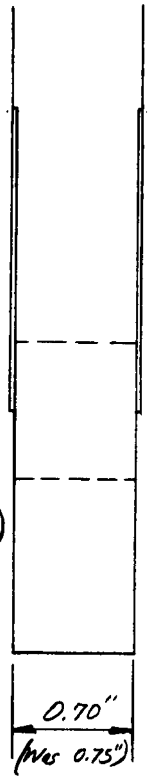
BY: Schultz

CHK. BY: WIEG

DATE: 8-28-62

Revision to Lug ~





Section modulus @ Sec X-Y

$Z = \frac{(0.99)^2 (0.70)}{6} = \underline{0.114 \text{ in}^3}$

$A = (0.70)(0.99) = 0.70 \text{ in}^2$

Ring Action ~

$M = KPr \doteq (0.28)(9700)(0.885) = 2400 \text{ in-\#}$

$\frac{R}{C} = \frac{0.885}{0.495} = 1.79 \quad \therefore \quad K_i = 1.63$ (Roark Case 1 Pg. 198)

$\text{Max. bending} = f_b = \frac{M K_i}{Z} = \frac{(2400)(1.63)}{0.114} = \underline{34{,}200 \text{ psi}}$

$\text{Des. Factor} = \frac{60{,}000}{34{,}200} = \underline{1.75:1}$ Just bend, OK

Max. Shear Stress ~

Pg 147 Roark

$\tau = \frac{3}{2}\frac{V}{A} \times (1.10) = (1.10)\left(\frac{3}{2}\right)\frac{9700}{2}\left(\frac{1}{0.70}\right) = \underline{11{,}450 \text{ psi}}$

$\text{Des. Factor} = \frac{35{,}000}{11{,}450} = 3.06:1$

Aerojet-General Corporation
Sacramento, California

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The Aerojet-General Utility van successfully completed structural tests to verify the acceptability of the van as a transport vehicle for second-stage Minuteman operational motors. The van and tie-downs were subjected to limit loads to determine stress levels at critical load points and to measure vehicle deflection and recovery from the downward and side loads imposed.

UNCLASSIFIED

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II. Air Force Ballistic Systems Division, Air Force Systems Command, USAF

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